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MODEL ERROR OF THE ROTATION CAPACITY OF REINFORCED CONCRETE PLASTIC HINGES FOR PERFORMANCE-BASED DESIGN

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TRABAJO FINAL DE MASTER

To my mother and my father that gave me the opportunity.

Abstract

The study of the rotational capacity of reinforced concrete elements and their ductility capacity have been of great interest in structural engineering, because, in our days, the design of structures is largely developed in the linear behavior of the materials (elastic range) and therefore of the structures, which makes us waste an extra capacity that the material has in its non-linear range. Mander in the 80s proposed a method based on the optimal confinement of reinforced concrete that would allow to consider in an appropriate and accurate way the behavior of this structural material in its non-linear range (inelastic or plastic range) taking into account that the material, when reaches this behavior generates what we now call plastic hinges. In the last decade Professor Bairan, tutor of this thesis, used this model and modified it for its possible application to the current structure design. This analytically developed method presents an error in terms of the actual behavior of the structures and their plastic hinges. This thesis is based on the collection of approximately 150 beams and columns experimentally failed by other researchers in order to determine which one is the error between the method and the measured information in real experiments in reinforced concrete beams with rectangular geometry. In the same way, the collection of these experimental data is used to compare the results with the current method used by the Eurocode for the confined concrete and the plastic hinges and thus determine how accurate the method is or how far from reality it is. Once the error is obtained, a lognormal probabilistic analysis is used to find some coefficients dependence of a probability of fail given, that could correct the results of both methods and thus generate more optimal designs and, in real terms, more efficient and economic structures.

Resumen

El estudio de la capacidad de rotación de los elementos de Concreto Reforzado y su capacidad de ductilidad ha sido de gran interés en la ingeniería de estructuras, debido a que, en nuestros días, el diseño de estructuras está desarrollado en gran medida en el comportamiento lineal del este material (rango elástico) y por ende de las estructuras, lo que nos hace desperdiciar una capacidad extra que tienen los material en su rango no lineal. Mander en la década de los 80 propuso un método basado en el óptimo confinamiento del concreto reforzado que permitiera considerar de una manera apropiada y precisa el comportamiento de este material estructural en su rango no lineal (rango inelástico o plástico) teniendo en cuenta que el material al entrar en esta zona de comportamiento genera lo que hoy llamamos rótulas plásticas. En la década pasada el profesor Bairan, tutor de esta tesis, utilizó este modelo y lo modificó para su posible aplicación al diseño de estructuras actual. Este método desarrollado analíticamente presenta un error en cuanto al comportamiento real de las estructuras y de sus rótulas plásticas. Esta tesis se basó en la recolección de aproximadamente 150 vigas y columnas falladas experimentalmente por otros investigadores para así poder determinar cuál es ese error entre el método y la realidad presente en elementos de concreto reforzado con geometría rectangular. De la misma forma se aprovechó la recolección de estos datos experimentales para comparar los resultados con el actual método utilizado por el Eurocódigo para el concreto confinado y las rótulas plásticas y así poder determinar que tan preciso es el método o que tan alejado de la realidad se encuentra. Una vez obtenido el error se procedió a utilizar un análisis probabilístico de tipo Lognormal para así poder encontrar un coeficiente de seguridad que pueda ser usados para ambos métodos y de esta forma generar diseños más óptimos y en términos reales de la construcción, diseños más eficientes y económicos.

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1. Introduction

1.1. Background

Reinforcement concrete nowadays is still the main structural material in all infrastructure and building constructions that is why experimental process to determinate the accuracy behavior of this material is still in progress.

The study of the rotational capacity of the RC beams has been of special interest since the sixties decade, in relation with the ductility of the RC beams, looking forward to optimized the design of it. Since the sixties, different researchers have made several experimental trials to determinate the behavior of the RC beams and its rotation capacity founding that the RC beams in their no Linear behavior present a higher ductility that the one actual design is taking into account, for example the actual EC2. This higher ductility, is just the difference between the rotation happened at the yield point of the material and the rotation happened at the ultimate load.

This plastic rotation occurs in a determined length creating was is called as plastic hinge.

It is important to bear in mind that for a plastic hinge to be generated, steel must be high ductility steel. The steel industry in Spain produce steel bars with some special characteristics in the ductility behavior, included in the EHE manual. The deformation capacity in the plastic range of this type of steel, and indeed there rotational capacity, is considerable higher than conventional steels (Bairán García 2007).

Mander(Mander and Priestley 1989) in a theoretical analysis, explained in chapter 2, demonstrate that this rotational capacity is specially given by a confinement of the concrete with the steel reinforcement, but in a higher way by the transversal reinforcement; a Theoretical stress-strain model for confined concrete was developed for member with either circular or rectangular sections, under static dynamic axial compressive loading, either monotonically or cyclically applied. After this work, Mander published a companion paper (Mander 1989), this paper studied the behavior of 31 nearly full-size reinforcement concrete columns, of circular, square, or rectangular wall cross section, with various arrangements of reinforcement tested in the laboratory, to contrast the model propose in the theoretical analysis with an experimental results. The results present an accepted error. In chapter 2 this is going to be shown.

This confined core, which gives more ductility to the member, has a high range of use in members as very request columns that can fail fragile because of an excessive compression in the concrete, bridge substructures, and others.

The actual EuroCode (from here onwards it will be called EC2) doesn’t have into account the capacity of the beam to rotate after reaching its yield point, implying the conservative calculation that this method proposes. This model is going to be explained in chapter 2.

1.2. Motivation

The accuracy of the design, special in seismic hazard zones, presents special interest due to its implications in the money cost, that is why a coefficient that make results more accuracy with the reality is try to be found.

As explain in 1.1 the actual EC2 handles a deformation for the confined core much lower than the one showed by the experiments, which could lead to induce, that the EC is on the side of safety, but maybe too much. It is precise to optimize the design.

It is important to determinate an accuracy plastic hinge length, because, as you will confirm in this paper, there is no only one option to calculate the plastic hinge region. For decades, researches have try to determinate de precise zone where the plastic deformation is concentrated and it has not been an easy research. As a parameter, the length of the plastic hinge zone is very important and should be provide intense confinement to increase ductility of the member to adequately resist the design stresses of an earthquake.

In the design of earthquake-resistant structures the ductility of the members for cyclical loads is an easy way to dissipate energy in an economical way. That is why guaranteeing the behavior of confined reinforced concrete is the most used way to dissipate energy (Bairán García 2007).

It is important to note that taking into account the behavior of the material under the non-linear range allows us as designers to apply a distribution of stresses, which will allow to diminish the positive moments (normally greater) and increase the negative ones. This distribution of stresses that is taken into account, precisely, by the formation of plastic hinges allows a more optimal design and therefore more economical constructions.

Based on the foregoing, we find as motivation the generation of safety coefficients for EC2, Mander-Bairan formulas that can be applied to the entire euro zone but also to be used around the world, taking into account this capacity of reinforced concrete and especially reinforced concrete confined, taking us to a material optimization (reduction) that can represent a significant economic saving for infrastructure development and indeed to their governments.

1.3. Objectives

The objectives for this thesis are:

- Clarify the state of the art of the different methods are going to be used and study in this paper, their evolution over time and their reason to be.
- Calibrate the plastic hinges model elaborated by Professor Bairan, based on Mander model, to this thesis, include the calculus of the EC2.
- Create a database with the recompilation of as many experimental trials as possible that had studied the rotation capacity in rectangular RC Beams. This database must have all the geometrical and materials properties needed to make a right calculus of the section.
- Create a database with all the results of the different sections collected in the database above, including their different states of moments, curvatures and rotations.
- It is important to keep in mind that this databases (both) are of great help for future studies since they collect all the information of more than 5 papers written around the world and at the same time they make a theoretical analysis of the info collected through the Mander-Bairan and EC methods
- Find an error between the Mander and Eurocode theoretical models and the experimental results.
- Choose a probabilistic method that fits in the data collected.

- Make a reliability analysis (bases on the probabilistic method chosen) of the results (error) and find a coefficient that make of the results of rotation capacity more accuracy for both methods.
- Recommendations for future studies

1.4. Overview

This thesis is divide in three big steps and 7 chapters.

The second chapter is about the state of the art of the subjects we are going to talk about. The concrete, steel and reinforced concrete behavior. The explanation of the Mander method and the modification made by Bairan to the model, in the same way, the study of method included in the EC2 and the difference between this two methods. The plastic hinge zone is going to be studied as well, and is going to determine which formulae for the plastic hinge propose is the one that can be adapted in the best way to the results, should be consider that the study of the plastic hinge region is a thesis itself. Finally, the probabilistic method to be used is going to be explained, their characteristics and consequences in the final coefficient result.

In the third chapter it will be shown all the experiments collected for this thesis, including the different type of loads used, their mechanical properties and their geometrical properties. The data base is going to be generated.

The fourth chapter explains the model used to calculate the rotational capacity of the beams by the method of Mander-Bairan and EC2, this model, developed by Professor Bairan and modify in some way by myself, is an excel program that shows us the different moments that occur in the beam in a theoretical way, such as the moment in a certain crack width, the moment of yield of the concrete, the moment of steel yield and the ultimate moments, in the same way allows us see in a graphic way the capacity of rotation of the beam and at the same time the capacity of ductility that each beam presents. The model also allows us to take into account the interaction of the shear on the beam and allows us to analyze the percentage of affectation on the capacity of ductility of the different specimens by means of an iterative analysis also presented in a graphical way of shear versus displacement, for example.

The fifth chapter shows the result of the database generate and the results of the models studied. The rotational capacity of all the beams are found in a theoretical way and compare with the experimental results, finding an error between them. This error is the first important result that will be found, because all this errors are the one that are going to be used in the probabilistic model to find the calibration coefficient, main objective of this thesis.

The sixth chapter is about the probabilistic model used to find the calibration coefficient, it will be explained totally as the different variables needed to run the model, the process of it and the specific characteristics that this model has to be correctly used in our calculation. In this chapter we are going to find the main goal of the thesis, the calibration coefficient.

Chapter seventh presents the most important conclusions of this paper, including the final objective of the paper and some recommendations for future studies in this special subject.

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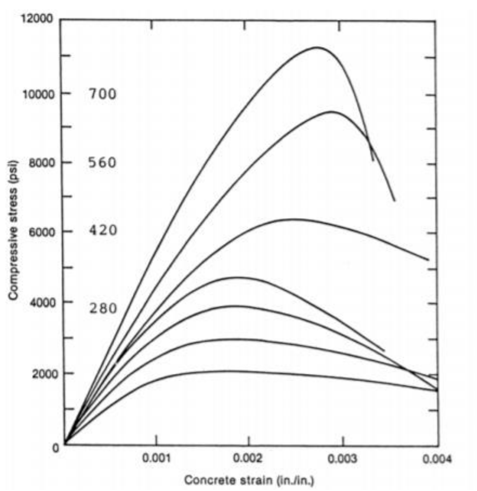
2. State of the Art

2.1. Materials Behavior

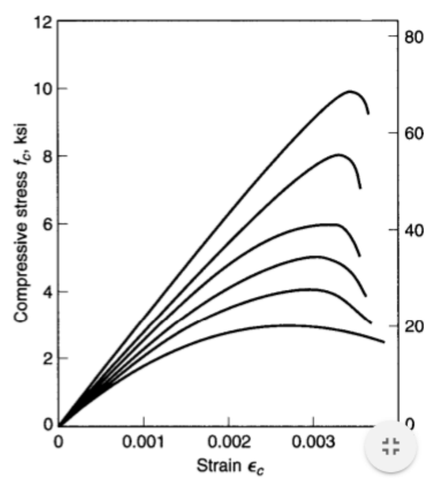
2.1.1. Characteristics of Concrete

The value adopted in the design for compression strength is the design characteristic strength fck, called as well the specified characteristic strength or design strength(EHE-08 2010). This compression strength is usually tested trough the experimental trial of simple compression on standardized cylindrical specimens with height / diameter ratio equal to 2 (Illustration 1). This is the behavior of concrete under uniaxial loads. In the Graphic 1 (Nilson 2008) it can be seen the usual behavior of typical compressive stress-strain curves for normal density concretes. Graphic 2 shows stress-strain curvatures for lightweight density concretes (Nilson 2008).

Illustration 1. Experimental test – Simple compression



Graphic 1. Stress Strain for Normal density Concrete. (Arthur Nilson, 2010)

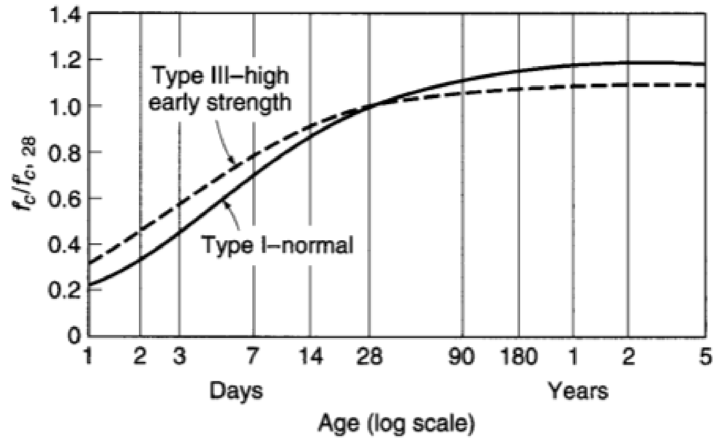


Graphic 2. Stress-Strain Lightweight density Concrete. (Arthur Nilson, 2010

All the curve have a similar behavior of an initial straight elastic part in which stress and strain are almost linear, mathematically this part is considered proportional. At 60% of the concrete resistance it began a non-linear behavior. At this point micro cracking begin to appear (Illustration 2). When it reaches the maximum stress (compressive stress) strain is about from 0.002 to 0.003. After rich the maximum stress the curve present a descending branch, all in the non-linear behavior of the material. The characteristics of the curves after the peaks depends of the method of testing. The compressive strength for normal density concrete fck is commonly in the range from 21 MPa to 35 MPa (prestressed concrete members fck of 56 MPa). This strength value fck is the value corresponding to the 5% quantile in the compression strength distribution of the concrete supplied (EHE-08 2010).

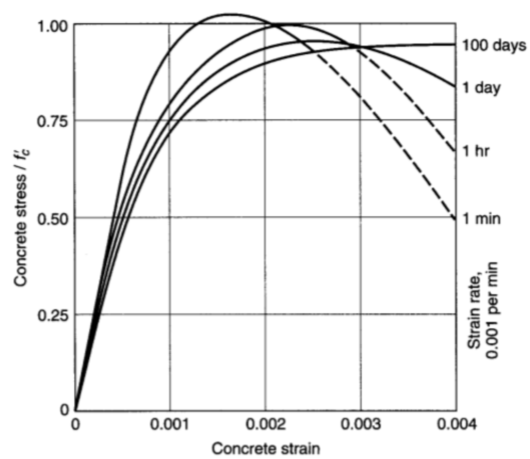
Illustration 2. Micro cracking on concrete.

This characteristics of the concrete are usually obtained through test made 28 day after placing, but cement continues hydratase and concrete continues harden but at a decrease rate (Graphic 3.

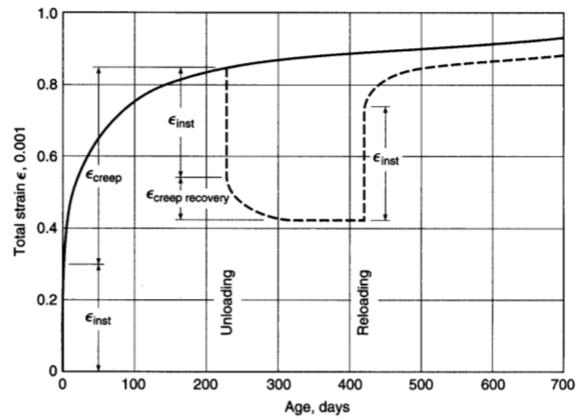


Graphic 3.

Long term load over the concrete decrees it resistance, it means that at a constant stresses the concrete suffers a slow deformation over considerable length of time, this effect is called creep. Graphic 4 shows the decrease of strength for different type of concretes trough the time. This is the reason why the European code and the American code includes a factor of 0.8 and 0.85 respectively to the characteristic value of fck. Graphic 5 shows in a schematic way the behavior of the concrete when have a constant load (stresses) and is unloading and loading again, we can deduce that there is a residual stress cause by what is called creep.



Graphic 4



Graphic 5

Creep can be consider with a creep coefficient consider in the next table(ACI 1985) and the formulae raised by the Branson (Branson and Christiason 1971).

Typical creep parameters

Compressive Strength		Specific Creep δ_{cu}		
psi	MPa	10^{-6} per psi	10^{-6} per MPa	Creep coefficient C_{cu}
3,000	21	1.00	145	3.1
4,000	28	0.80	116	2.9
6,000	41	0.55	80	2.4
8,000	55	0.40	58	2.0
10,000	69	0.28	41	1.6
12,000	83	0.22	33	1.4

Table 1. Typical creep parameters

$$C_{ct} = \frac{t^{0.60}}{10 + t^{0.60}} C_{cu}$$ …………………………….(1)

Formula 1. Creep coefficient

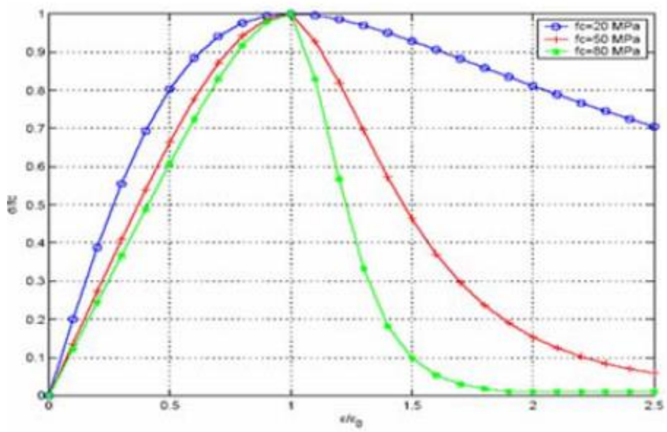
t = time in days after loading

Fluctuation loading rather than sustained it is what is called fatigue strength that is considerably smaller that its static strength. Cycling loads (10 E6) can make this type of failure to appear.

The behavior in tension is also important but much of the time is depreciable. There are considerable difficulties to test a concrete specimen in true tension and because of that the true tension strength of the concrete. In direct tension tests the stress concentration over the grips makes lose the accuracy of the results so the most common used is the split-cylinder test that give us an indirect stress fct, that is not identical to the true axial tensile strength but are a good measured of.

The ACI found better correlation between the tensile strength and the square root of the compressive strength, depending of the concrete density the tensile stress range is from $2\sqrt{fck}$ to $5\sqrt{fck}$.

The stress-strain diagram for tensile strength of the concrete is linear until it reaches the maximum resistance, after this there is an abrupt decreasing part which means a very fragile behavior, this is the reason why tensile strength is not consider at ultimate limit state (Graphic 1) (Bairán García 2007).

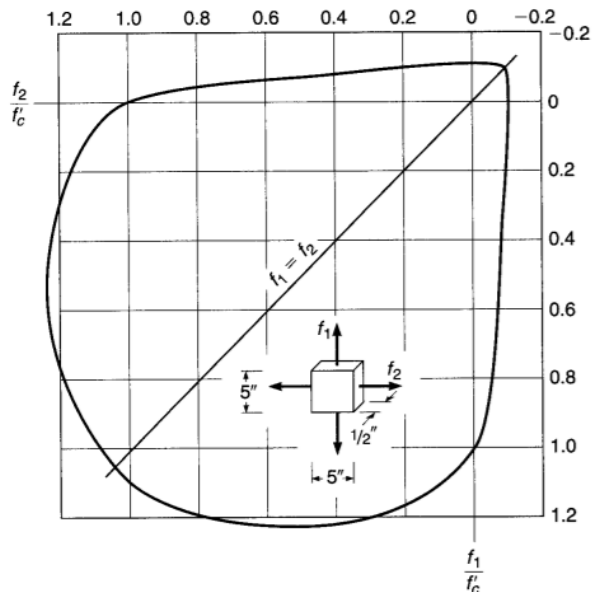


Graphic 6. Stress-stress Tensile behavior for different strength concretes.

In many cases, concrete is subjected to stresses acting in different directions, it means multiaxial loads or combined stresses. For example, beams are subjected to compression and shear stresses; footing and slabs present compression in two directions plus shear. Any state of stresses can be reduce to three principal stresses acting at rectangular angles to one another in a cube. If one of this stresses is zero it is going to be considered biaxial stress and if two are zero is going to be consider uniaxial.

There is not a general theory of strength for concrete under multiaxial loads, but there are some theories accepted as Mohr-Coulumb, maximum stress and the octahedral shear stress theories, all have been adopted in structure mechanics texts due time with partial success in concrete behavior. The difficulty for develop an accuracy theory is because of the nonhomogeneous nature of concrete influenced by microcracking (Nilson 2008).

The biaxial behavior of the concrete has been successfully found in experimental trials (Kupfer and Hilsdorf 1969) presented in the form of an interaction diagram (Tasuji 1978) (Graphic 7).



Graphic 7. Interaction diagram biaxial. (adapted from Tasuji y Kupfer, 1978) (Tasuji 1978)

In the representative biaxial compression quadrant the graphic shows an increasing percentage of 20 over the uniaxial compressive strength is attained. In the biaxial tension quadrant strength in direction 1 is independent of stress in direction 2. Otherwise when tension in one direction is present with compression in the other direction strength suffer a linear decrease.

The significant restrains from the loading equipment introduce when applying load in three direction to an specimen in tests make of experimental investigations to be practical difficult (Gerstle 1978). Nilson (Nilson 2008) make three conclusions with the information available for triaxial stresses states. 1.) “In a state of equal triaxial compression, concrete strength may be an order of magnitude larger than the uniaxial compressive strength. 2.) For equal biaxial compression combined with a smaller value of compression in the third direction, strength increase greater than 20 % can be expected. 3.)For stress state including compression combined with tension in at least one other direction, the intermediate principal stress is of little consequence, and the compressive strength can be predicted safely base on Graphic 7". Strength of concrete cannot be calculate rationally yet. The design of concrete structures are more based in experimental trials than in an analytical theory.

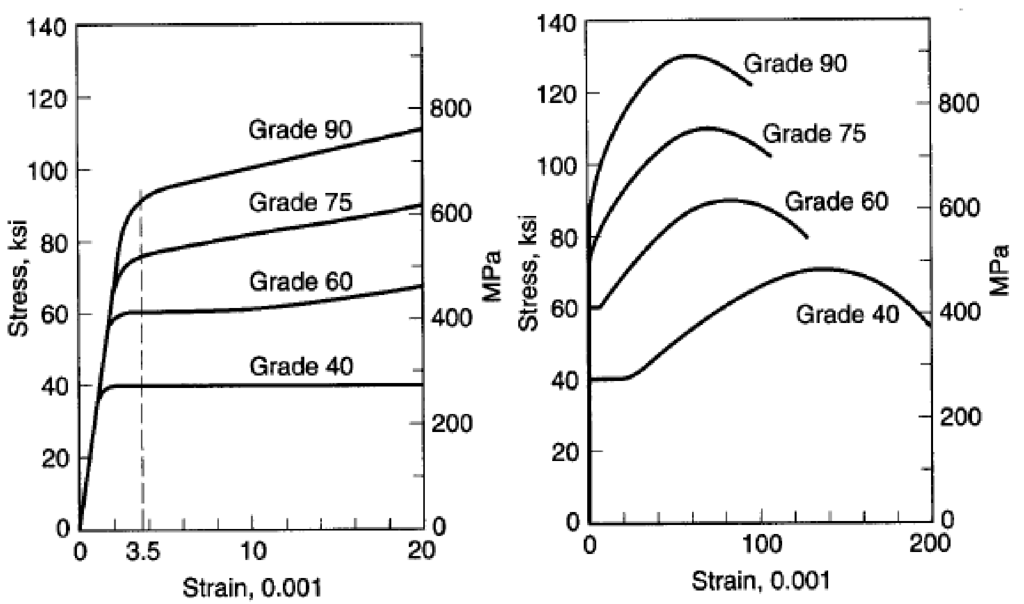
2.1.2. Characteristics of Reinforcing Steel

Steel behaves almost the same way when it works over compression as in tension and can resist higher capacities than concrete but still it is a high-cost material compare to concrete. The combination of both materials is great if the concrete is made to resist compression stresses and the steel is made to resist tension stresses. Thus, in reinforced concrete, concrete resist the compression forces and the longitudinal steel bars are located very close to tension face to resist tension forces. In the same way, steel fulfills an important function that is to resist the shear stresses on the beam. In some special cases the reinforcement can be used to resist compression efforts in order to decrease the cross section of the element. Even, the reinforcement is placed in minimum amounts in all compression members to resist occasional efforts that can crack or break the element.

Bond between both materials is very important so that there is an equal deformation for the two materials to ensure that there are no relative movements between them. This bond is due to a chemical reaction.

The stress-strain curves for steel is characterized by a linear behavior (elastic behavior) until reaching its yield point (elastic limit) fy, from there it is considered a small plastic branch that have zero slope (which as we see in figure 8 is not exactly zero, but could be considered as). Once an approximate deformation of 0.02 has been reached, the nonlinear part (inelastic behavior) begins, where two different situations are presented. The first is known as hardening until reaching its maximum resistance. Once this peak is reached, what we know as softening occurs, steel continues to deform but loses resistance capacity.

The stress-strain curves for different types of steels are shown in **¡Error! No se encuentra l origen de la referencia.**. Left part of the graphic represents the initial portion of the curves magnified 10 times, the right part shows the complete stress-strain curves.



Graphic 8. Stress-strain curve for different types of steel.

Ductile steel in the EHE (2007) is characterized in two categories: Normal Ductility and Special Ductility. The values for steels required by the Spanish code can be found in the following table (Table 2. Mechanic Characteristics for EHE steels.

Tipo de acero	Soldable		Soldable con características especiales de ductilidad	
Designación	B 400 S	B 500 S	B 400 SD	B 500 SD
Límite elástico, f_y (N/mm2) (1)	≥ 400	≥ 500	≥ 400	≥ 500
Carga unitaria de rotura, f_s (N/mm2) (1)	≥ 440	≥ 550	≥ 480	≥ 575
Alargamiento de rotura, A5 (%)	≥ 14	≥ 12	≥ 20	≥ 16
Alargamiento total bajo carga máxima, $\varepsilon_{máx}$ (%)	≥5,0	≥5,0	≥ 9,0	≥ 9,0
Relación f_s/f_y (2)	≥ 1,05	≥ 1,05	≥ 1,20 ≤1,35	≥ 1,15 ≤1,35

Table 2. Mechanic Characteristics for EHE steels

For B400S y B400SD type of steels, the Spanish code allows different values for maximum characteristic deformations emax.

	ε_{max}
B400S	0.08
B400SD	0.124

Table 3

In the other hand, ASTM present their own table for the minimum values for strength requirements in steel (Table 4). Most of Latin-American Seismic Codes are based on ACI instructions.

TABLE 2.4
Summary of minimum ASTM strength requirements

Product	ASTM Specification	Designation	Minimum Yield Strength, psi (MPa)	Minimum Tensile Strength, psi (MPa)
Reinforcing bars	A615	Grade 40 Grade 60 Grade 75	40,000 (280) 60,000 (420) 75,000 (520)	60,000 (420) 90,000 (620) 100,000 (690)
	A706	Grade 60	60,000 (420) [78,000 (540) maximum]	80,000 (550)[a]
	A996	Grade 40 Grade 50 Grade 60	40,000 (280) 50,000 (350) 60,000 (420)	60,000 (420) 80,000 (550) 90,000 (620)
	A1035	Grade 100	100,000 (690)	150,000 (1030)
Deformed bar mats	A184	Same as reinforcing bars		
Zinc-coated bars	A767	Same as reinforcing bars		
Epoxy-coated bars	A775, A934	Same as reinforcing bars		
Stainless-steel bars[b]	A955	Same as reinforcing bars		
Wire Plain	A82		70,000 (480)	80,000 (550)
Deformed	A496		75,000 (515)	85,000 (585)
Welded wire reinforcement Plain W1.2 and larger Smaller than W1.2	A185		65,000 (450) 56,000 (385)	75,000 (515) 70,000 (485)
Deformed	A497		70,000 (480)	80,000 (550)
Prestressing tendons Seven-wire strand	A416	Grade 250 (stress-relieved)	212,500 (1465)	250,000 (1725)
		Grade 250 (low-relaxation)	225,000 (1555)	250,000 (1725)
		Grade 270 (stress-relieved)	229,500 (1580)	270,000 (1860)
		Grade 270 (low-relaxation)	243,000 (1675)	270,000 (1860)
Wire	A421	Stress-relieved	199,750 (1375) to 212,500 (1465)[c]	235,000 (1620) to 250,000 (1725)[c]
		Low-relaxation	211,500 (1455) to 225,000 (1550)[c]	235,000 (1620) to 250,000 (1725)[c]
Bars	A722	Type I (plain) Type II (deformed)	127,500 (800) 120,000 (825)	150,000 (1035) 150,000 (1035)
Compacted strand[b]	A779	Type 245 Type 260 Type 270	241,900 (1480) 228,800 (1575) 234,900 (1620)	247,000 (1700) 263,000 (1810) 270,000 (1860)

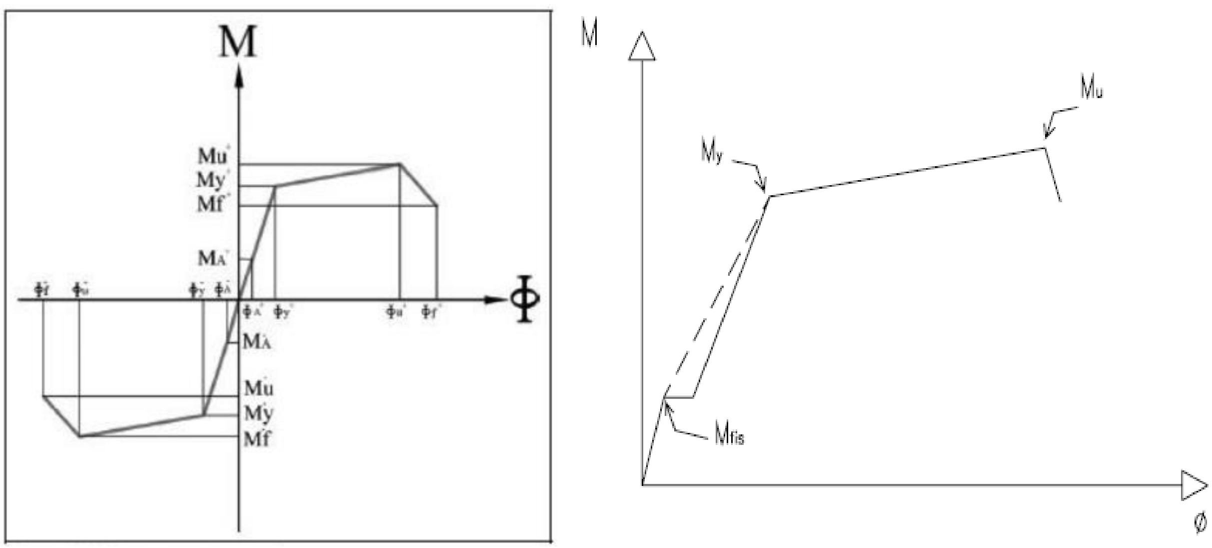
[a] But not less than 1.25 times the actual yield strength.
[b] Not listed in ACI 318.
[c] Minimum strength depends on wire size.

Table 4

2.1.3. Reinforcement Concrete

When beams are subjected to simple bending, with reinforcement on both tension and compression faces (as all experimental cases consider in this paper), the curvature of the beams can be calculated in an analytical way, a curve moment-curvature has been obtained, which represents in a correct way, not entirely accurate, the behavior of this type of beams and their ductility capacity.

In a cross section level, it can be deduce three different behaveiors of the material in the moment-curvature curve (Graphic 9).



Graphic 9. Typical Diagram Moment-Curvature for a RC beam (Kent, Park 1969) – (Negro)

a. The first part of the curve, present an elastic (Linear) behavior of the reinforcement concrete. The stiffness of the material is given by all the cross-section, until the first crack appears in the concrete (point A in left graphic- Mfis in the right graphic).

b. The crack starts to grow and because of this the stiffness of the cross section decrease (A to Y point in right graphic), but in some cross section points between two cracks, the concrete is still under compression stresses, it means that the actual slope of the curve in graphic 9 is not zero, as shown in in right graphic but it is the slope of the striped line (Bairán García 2007). This slope is considered constant until the material reaches its yield point due to the steel traction (point Y).

c. The third part of the curve which is between the yielding point (Y) and the ultimate moment resistance (U) is characterized because of a significant decrease of the stiffness and can be define by three different types of behavior.

    - Fragile rupture due to insufficiency of the traction reinforcement: This type of failure happens when the element's tensile reinforcement is not enough to withstand the stresses that have occurred. With a provision of minimum reinforcement amount according to actual Seismic codes this problem can be solved.
    - Ductile rupture: This type of failure happens when the steel reinforcement reaches its yield point and enters its plastic behavior, which allows the section to continue to bend (curvature) but does not allow it to resist more moment, this increase of the curvature is what we understand as ductility. This type of ductile failure warns before reaching its failure point by means of cracks in the section and very marked deformations. We must ensure this type of failure in order to force the material to behave in a much more ductility.Illustration 3. Ductile FailIllustration 3 shows how the beam warn with several cracks and an important deformation, the moment curvature curve denotes the ductility that can reach the section.
    - Fragile Rupture because of excessive compression in the concrete: As its name indicates, this type of failure is fragile, that is, it does not give notice and has a fast, almost explosive failure in of the concrete. This failure gives no ductility to the section. Illustration 4 shows how this type of

failure presents few cracks and deformation and in the moment curvature curve present no ductility.

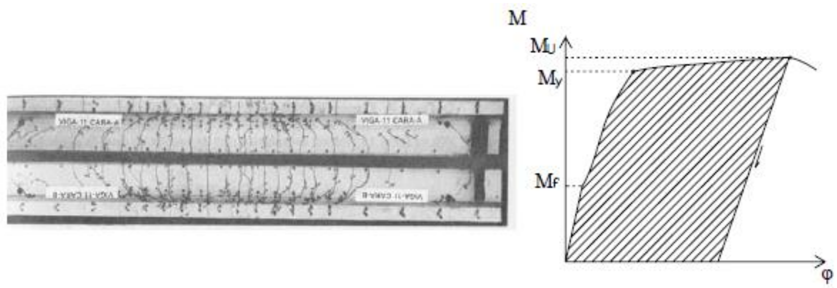


Illustration 3. Ductile Fail (Bairán García 2007)

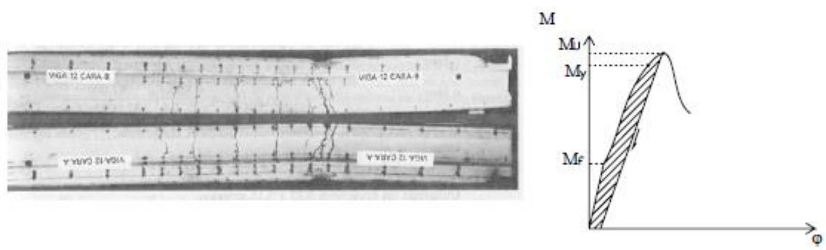


Illustration 4. Fragile Fail (Bairán García 2007)

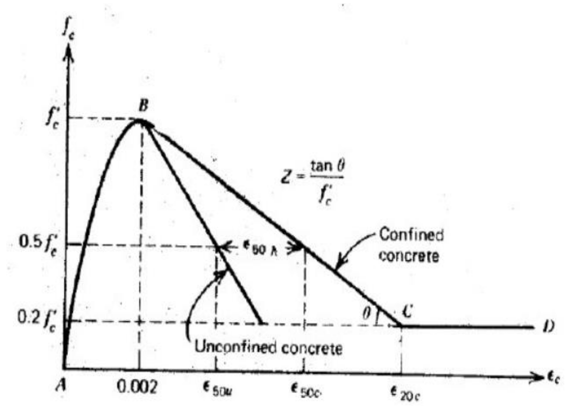
The ductility of the element is the coefficient between the ultimate curvature and the yield curvature, as expressed by (Bairán García 2007) the ductility is just the measured of the deformation capacity in the non-linear range without losing the capacity of resisting load.

$$\mu_{\emptyset} = \frac{\emptyset_u}{\emptyset_y} \qquad (2)$$

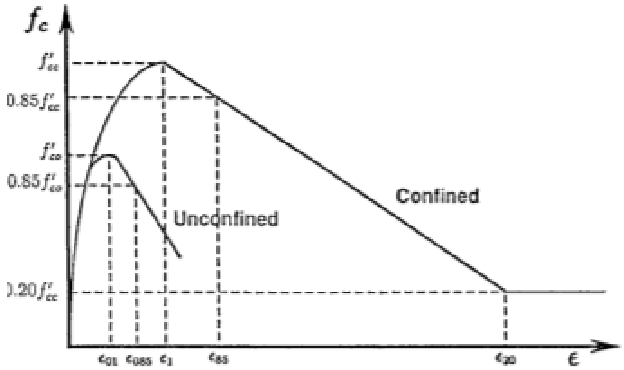
2.2. Constitutive Model For Confined Concrete under Monotonic Loads.

The stress-strain curve of concrete with increasing monotonic load is an envelope of the one obtained in a cyclical way. This can be verified with studies carried out by several researchers, in where the points of the envelope curve obtained for different load cases and different qualities of concrete are plotted. The envelope curve must be considered unique for each capacity resistant of a concrete analyzed and independent of the history of applied load. (Park and Paulay 1991), (Mander and Priestley 1989).

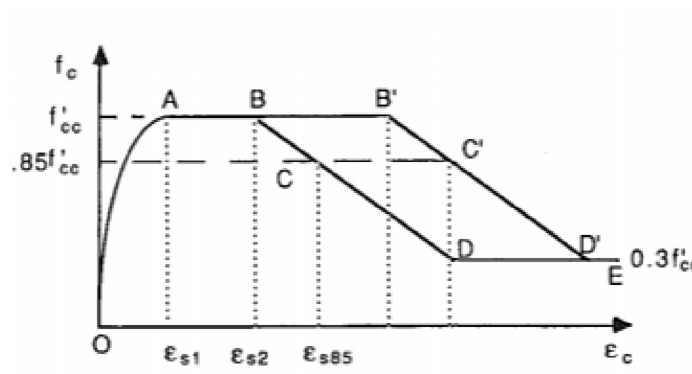
In the last decades several constitutive models have been developed to represent the confined concrete with results very close to experimentation, among these are models from (Kent and Park 1971); (Sheikh and Uzumeri 1982); (Mander and Priestley 1989); (Razvi and Saatcioglu 1992). All these are valid for both confined concrete and unconfined concrete. Graphic 10, Graphic 11 and Graphic 12 presents different types of constitutive models propose by the named authors (stress-strain curves), none of this models are going to be used in this thesis, but is very important to compare the behavior of each and understand why Mander is, nowadays, more used.



Graphic 10. Constitutive model for confined concrete, (Kent and Park, 1971)



Graphic 11. Proposed Model by Razvi and Saatcioglu, 1992



Graphic 12. Stress-Strain Models of confined Cocrete (Sheikh and Uzumeri, 1982)

In this research the model of (Mander and Priestley 1989), which clearly represents the behavior of the confined concrete as well as obtaining the parameters to obtain the stress-strain diagram with and without confinement. In some regulations such the Eurocode and the ACI adopts this formulation for the definition of the stress-strain diagram of the confined concrete, which is the reason why this model is going to be used in this thesis. This model assumes the existence of a series of internal arcs supported by the stirrups of the transversal reinforcement that allows the confinement of the concrete core.

The equation raised by Mander was determined for an element subjected to uniaxial load and confined with transverse reinforcement. The concrete section can have any shape and type of transverse reinforcement. In addition, the rectangular sections may have different configurations of the stirrups of confinement in both directions of the transversal axes, as presented in the case of study. The model can take into account the cyclical loads as well as the speed of application of the load.

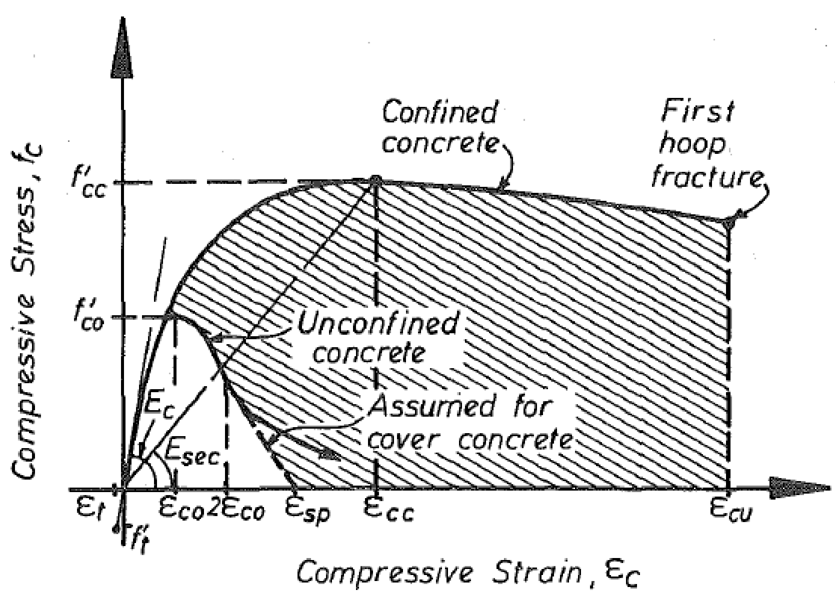
In the following diagram we can see that the maximum strength of concrete increases if it is confined: the stress-strain curve for confined and unconfined concrete is similar to a deformation $\varepsilon\_co = 0.002$. From this deformation the confinement steel begins to act on the concrete core increasing both the strength and its capacity to deform. Early investigation developed before Mander buy collected and used in his research showed that the strength and the corresponding longitudinal strain at the strength of concrete confined by an active hydrostatic fluid pressure can be represented by the following equations.

$f'_{cc} = f'_{co} + k_1 f_l$ .... (3)

$\varepsilon_{cc} = \varepsilon_{co} \times (1 + k_2 \frac{f_l}{f'_{co}})$ .... (4)

Where:

- f'_{cc} = The maximum concrete stress
- ε_{cc} = Strain at corresponding stress f'_{cc}
- f_l = Lateral fluid pressure
- f'_{co} = Unconfined concrete stress
- ε_{co} = Unconfined Concrete Strain
- k_1 = Coefficient of Concrete mix
- k_2 = Coefficient of Lateral Pressure



Graphic 13. Stress-strain Model propose for Monotonic Loading of Confined and Unconfined Concrete. Mander 1988

(Mander, Priestley, and Park 1984) proposed a unified stress-strain approach for confined concrete applicable to both circular and rectangular shaped transverse reinforcement. Based on equation suggested by Popovic 1973, the model shown in Graphic 13 is proposed for a slow strain rate and monotonic loading. Compressive stress is given by the following equation (Mander and Priestley 1989).

$$f_c = \frac{f'_{cc} x r}{r-1+x^r} \quad (5)$$

Relationship between strain of confined and unconfined concrete

$$x = \frac{\varepsilon_c}{\varepsilon_{cc}} \quad (6)$$

Strain at maximum stress of confined concrete

$$\varepsilon_{cc} = \varepsilon_{co}\left(1 + 5\left(\frac{f'_{cc}}{f'_{co}} - 1\right)\right) \quad (7)$$

Generally ε_{co} = 0.002 can be assumed (Richart and Brandtzaeg 1928).

Relationship between tangent Modulus of elasticity and Secant-Modulus of elasticity

$$r = \frac{E_c}{E_c - E_{sec}} \quad (8)$$

Relationship between tangent Modulus of elasticity and Secant-Modulus of elasticity

$$E_c = 5000\sqrt{f'_{co}} \quad MPA \ldots\ldots (9)$$

$$E_{sec} = \frac{f'_{cc}}{\varepsilon_{cc}} \ldots\ldots (10)$$

This model assumes that from a deformation of 2εco (εc> 2εco) exist a straight prolongation of the curve until the intersection with the x axe, as shown in the Graphic 13.

The confinement effect is made by the transversal and longitudinal reinforcement over the core's section and can be apply ass follow. Because of the Poisson's effect the longitudinal compressed concrete tends to expand in a transversal direction but the transversal reinforcement prevents this expand forming some type of arc of internal discharge supported on the stiffer stirrup points. This is the reason why, for the same diameter of stirrups and the same separation of transversal reinforcement, a circular cross-section presents a better confinement than the rectangular sections.

Several experimental researches have shown that circular stirrups have a better confinement effect over the core's section than the rectangular stirrups, this is because a circular shape produce an uniform pressure due the circumference rather than a rectangular stirrups produce confinement lateral pressure in the corners of the section since the lateral pressure over the core provokes buckling in the longitudinal reinforcement. In this thesis it is going to be a case of study only elements with rectangular cross-area. All the experiments collected in this work are rectangular elements.

A Confined beam can be illustrated as follows:

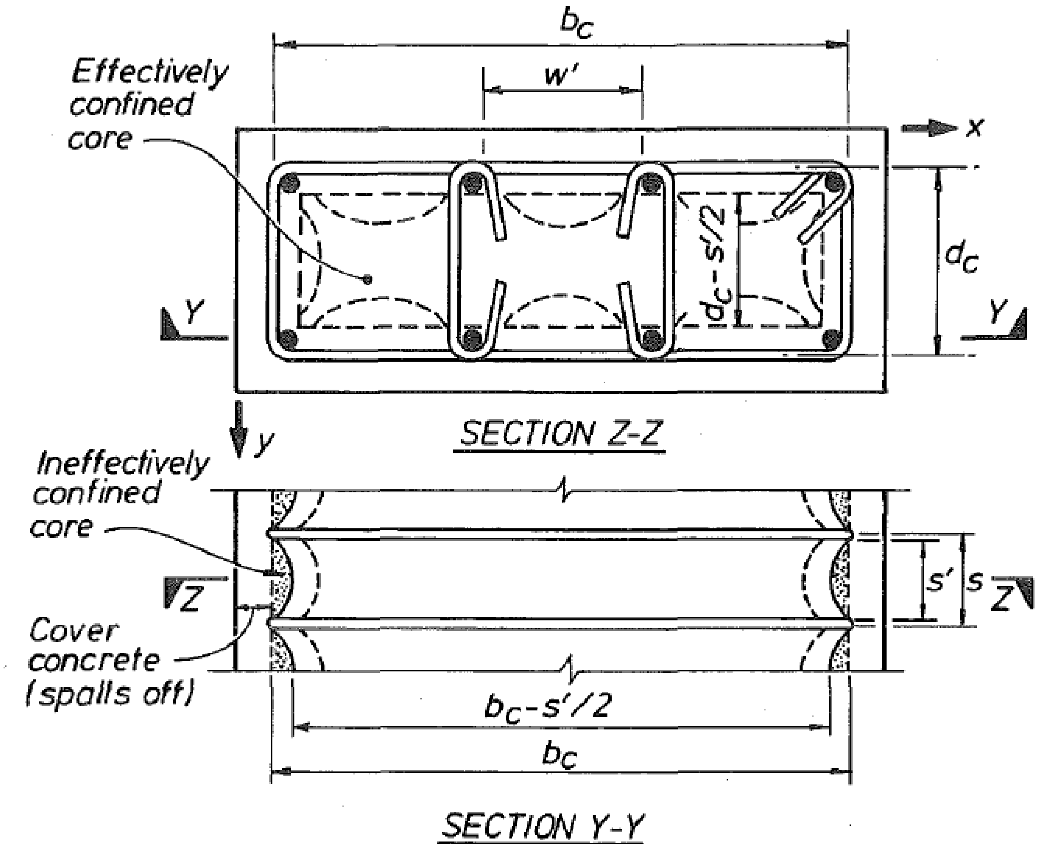


Illustration 5. Effectively Confined core for Rectangular Hoop Reinforcement (Mander and Priestley 1989)

As shown in Illustration 5 the rectangular cross section generates some type of parabolic shapes (discharge arcs) with an initial tangent of 45°. This parabolas exist both longitudinal and transversely. In a geometrical way it can be determinate that the highof the parabola with a chord named w' (Illustration 5) and an initial tangent of 45° is equal to w'/4 and its area is equal to $w'^2/6$, therefore the unconfined area for n parabolas formed between n longitudinal bars is:

$$A_i = \sum_{i=1}^{n} \frac{w\prime i^2}{6} \qquad (11)$$

Where:

w'i is the arc off each discharge parabola. Taking into account the existence of vertical parabolas between the different levels of stirrups, it can be calculated the confined area at the middle of the stirrups spacing $(s'/2)$ as:

$$A_e = (b_c d_c - \sum_{i=1}^{n} w'i^2)\left(1 - \frac{s'}{2bc}\right)\left(1 - \frac{s'}{2dc}\right) \quad (12)$$

Where:

bc = Confined width

dc = Confined high

dc =< bc

and ke can be deduce as:

$$k_e = \frac{\left(\sum_{i=1}^{n} \frac{(w'i)^2}{6b_c d_c}\right)\left(1-\frac{s'}{2b_c}\right)\left(1-\frac{s'}{2d_c}\right)}{1-p_{cc}} \quad (13)$$

By equilibrium of forces we can obtain:

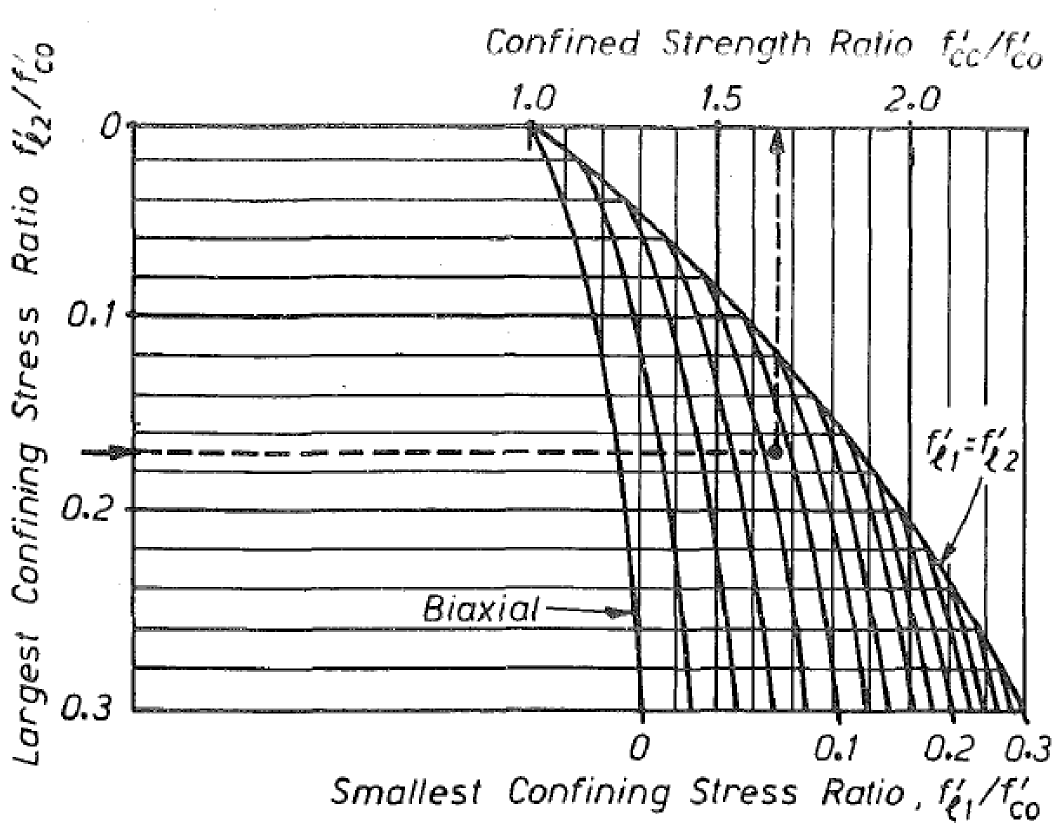
$$A_{sx} f_{yh} = f_{l,x}\, s\, d_c \quad (14)$$

$$A_{sy} f_{yt} = f_{l,y}\, s\, b_c \quad (15)$$

Where Asx ans Asy are the total area of transverse bars running in the x and y directions, respectively (see Illustration 5) and $f_{l,x}$ and $f_{l,y}$ are the lateral pressures in both directions respectively.

With the value of the lateral confinement stresses in both directions it can be used a tridimensional model of fail and obtain an expression for the maximum compression stress of confined concretef'_{cc}.

(Mander and Priestley 1989) propose the graphic below to calculate the maximum compress stress of confined concrete f'cc. With this value it can be used the strain-stress model for confined concrete given by the equations above (Graphic 14).



Graphic 14. Confined Strength Determination from Lateral Confining Stresses for Rectangular Sections

The ultimate concrete strain (ε_cu) is due to the stirrup fail and can be approximated by the follow equation (Park and Paulay 1991).

$$\varepsilon_{cu} = 0.004 + 1.4\rho s\ \frac{f_y \varepsilon_{sm}}{f'_{cc}} \quad (16)$$

Where ε_{sm} is the steel deformation at maximum tensional stress and ρs is the volumetric quantity of transversal reinforcement. For rectangular cross section $\rho s = \rho x + \rho y$ where

ρx and ρy are the transversal reinforcement quantities in both directions. $0.012 \leq \varepsilon_{cu} \leq 0.05$.

For the plastic hinge region it was used the formula propose by the EUROCODE based on different research papers (Zhao et al. 2011). The formula adopted is:

$$Lp = 0.1 \times \frac{M}{V} + 0.015\, Fi\ \times fyk \ldots\ldots (17)$$

2.3. Statistical Model

In this thesis it could be used different probabilistic methods, some of them are to complex for be developed in this research.

ANOVA method (Analysis of variance) for example is a method that can give us an accuracy results. This method is a collection of statistical model that can analyze the difference between groups in a sample, it provides a statistical test and therefore divide the tests in more than two groups, and so is a powerful tool for comparing testing for more than two groups for statistical significance. The database collected doesn't fit as well to this method because of the variance of the sampling in terms of difference in mechanism and geometric characteristics.

There is another procedure stablish by the JCSS (Joint Committee of Structural Safety) with a developed code and free access to it, but this method is focus on the development of safety factor for design structures, with three main parts: 1. Basis of the design, 2. Modelling of loads, 3. Modelling of structural properties. This method as a reliability analysis doesn't work for this research because it goes beyond the scope of this thesis when trying to find real safety factors for a complete structure, which is not the case since in this thesis analysis of beams submitted to simple bending is developed, so the computational code provided by this institution would have to be modified, which would be tantamount to developing an entire thesis on the subject.

What was done to determine the type of probabilistic method to use, was to assume a normal log distribution, based on experience and in different papers (Torrent 1979) (Van Coile 2013) that have approve the use of this type of probabilistic methodology for control of mechanical testing of materials. The use of this statistical distributions allows to develop structural reliability analysis and then find a calibration safety factor.

Then be able to use the cumulative probability function and check if the data (observations) fit to this type of distribution. The data fit perfect for the results in Mander and EC Method so it is going to be explain how the Lognormal distribution is used and its behavior. The lognormal distribution is used extensively in reliability applications to model failure times. The lognormal and Weibull distributions are probably the most commonly used distributions in reliability applications. (Evans, Hastings, and Peacock 2000).

A variable X is consider lognormally distributed if $Y = \ln(X)$ is normally distributed when the natural logarithm LN is apply. The general formula for the probability density function of the lognormal distribution is:

$$f(x) = \frac{e^{-\left(\frac{ln\left(\left(\frac{x-\theta}{m}\right)^2\right)}{2\sigma^2}\right)}}{(x-\theta)\sigma\sqrt{2\pi}} \qquad (18)$$

Donde:

$x > \theta; m, \sigma > 0$

σ is the standard deviation of the log of the distribution

θ is the location parameter

m is the scale parameter it means the median of the distribution

If x = θ then f(x) = 0. The case where θ = 0 and m = 1 is called standard lognormal distribution.

The equation for the standard lognormal distribution is:

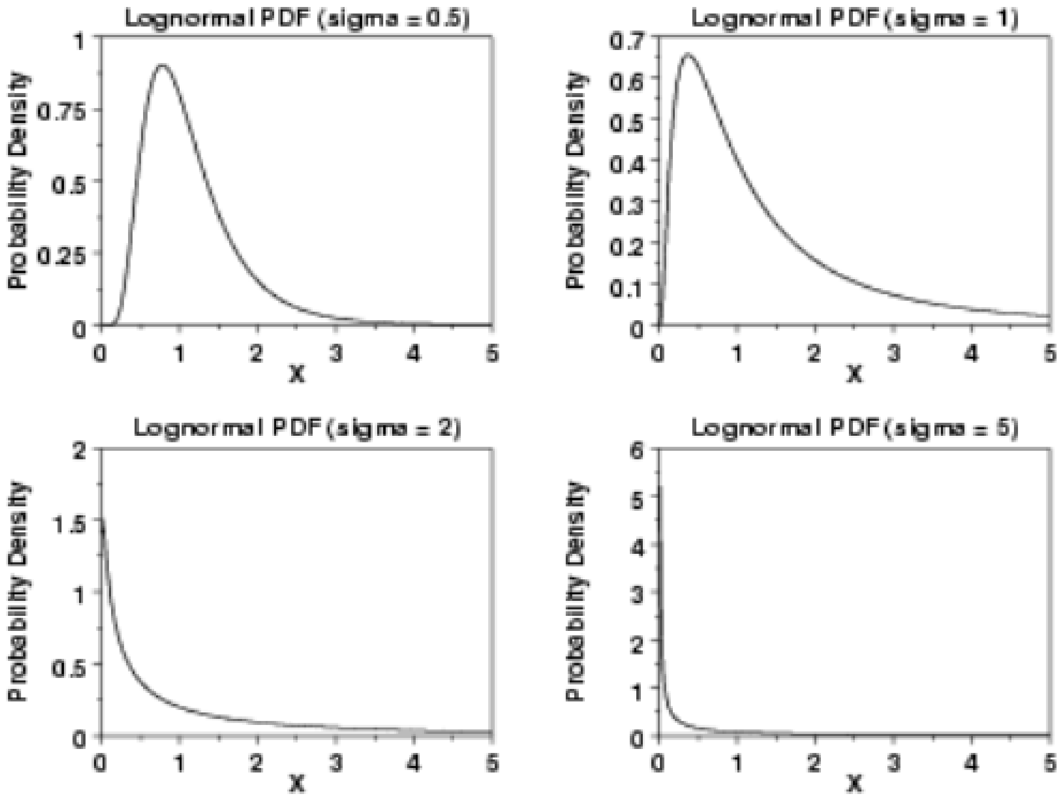
$$f(x) = \frac{e^{-\left(\frac{\ln x^2}{2\sigma^2}\right)}}{x\sigma\sqrt{2\pi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(19)}$$

Since the standard form of probability functions can be expressed in terms of the standard distribution, all the formulas are going to be given for the standard form of the function. Is important to realize that the lognormal distribution is commonly parameterized with μ = log (m). This μ is the mean of the log of the distribution. If the μ parameterization is used, the lognormal probability density function is:

$$f(x) = \frac{e^{-\left(\frac{ln((x-\theta)-\mu)^2)}{2\sigma^2}\right)}}{(x-\theta)\sigma\sqrt{2\pi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(20)}$$

$x > 0;\ \sigma > 0$

It is rather to use the m parameterization since m is an explicit scale parameter. The lognormal probability density function for different values of σ are shown below.



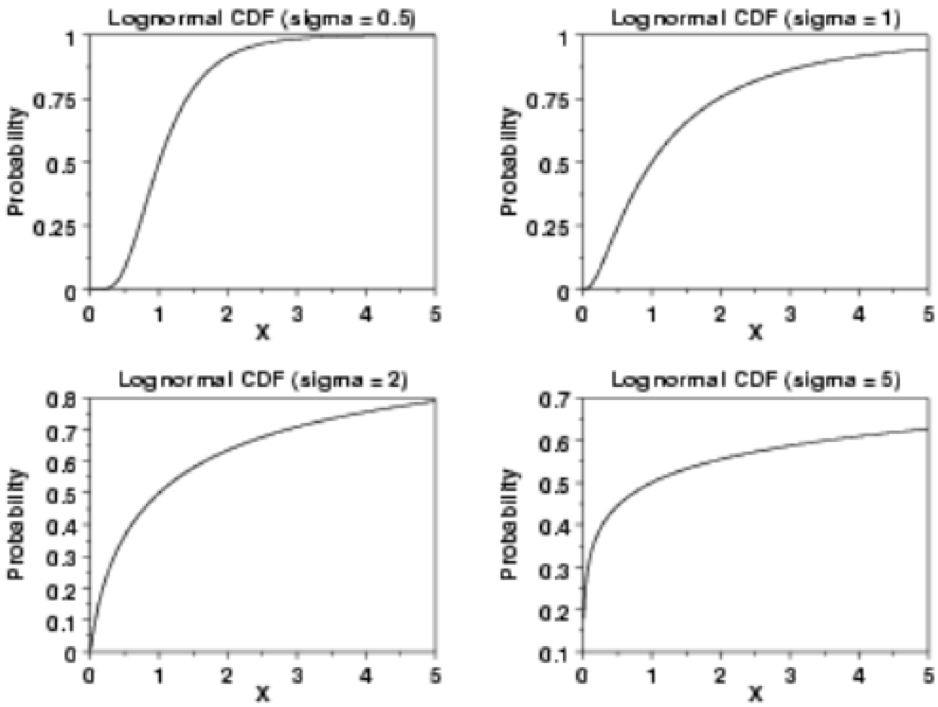
Graphic 15. Lognormal distributions (Evans, Hastings, Peacock, 2000)

The formula for the cumulative distribution function of the lognormal distribution is:

$$F(x) = \phi\left(\frac{\ln(x)}{\sigma}\right), \quad x \geq 0;\ \sigma > 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(21)}$$

Φ is the cumulative distribution function of the lognormal distribution.

The lognormal cumulative distribution for different values of σ are shown below.



Graphic 16. Lognormal cumulative distributions (Evans, Hastings, Peacock, 2000)

If the tests results fit a Lognormal cumulative distribution it means the probability density function of the lognormal distribution can be used.

General formula for any probabilistic distribution

$Mean \qquad m = e^{0.5\sigma^2}$ ………………………………..…………… (22)

$Median \qquad Me = \frac{\sum x}{n}$ ……………………………..……..…….. (23)

$Standard\ Deviation \qquad \sigma = \sqrt{e^{\sigma^2}\left(e^{\sigma^2} - 1\right)}$ …………..………………..….... (24)

$Coefficient\ of\ Variation \qquad cov = \sqrt{\left(e^{\sigma^2} - 1\right)}$…………..…………….............. (25)

Once, the probability density function is plotted, is important to determinate which is the percentage of error we want to deal with. For this thesis it has been choose a probability of fail equal to 90%. So the area below curve of the probability function excluding all the data outside the 90% is going to be our reliability index coefficient.

2.4. Estimation of factor of safety

Based in Eurocode (EN 1990. AEN/140 2003) a semi probabilistic method is used for the estimation of the safety factor, this methodology has been approve by different researchers (Cervenka 2006).

First we define the failure Probability on the basis that the resistance capacity (R) of the material is higher than the solicitations it have (E), define as:

$g = R - E$ ……………………………………………………………………..(26)

Failure probability:

$Pf = Prob\ (g \leq 0)$ ……………………………………………………………....(27)

Now based on the reliability index:

$\beta = -\emptyset^{-1}(Pf)$ …………………………………………………………………...(28)

It is introduce the Safety Factor (ϒ) through the next expression.

$\boldsymbol{\gamma_R = e^{\alpha_R \beta V_R}}$ **…………………………………………………………………………(29)**

Where

α_R is the sensitivity coefficient (usually adopted by the EC as 0.8)

β is the reliability index

V_R= σ/μ is the coefficient of variation.

3

3. Physical Experiments

3.1. Case Study

The case studies for this test are based on the collection of experiments documented over the past century on the rotational capacity of beams. Since the 1960s several researchers developed experimental tests to find such behavior. In this thesis we collected the largest number of available experiments based on characteristics that generate our case study.

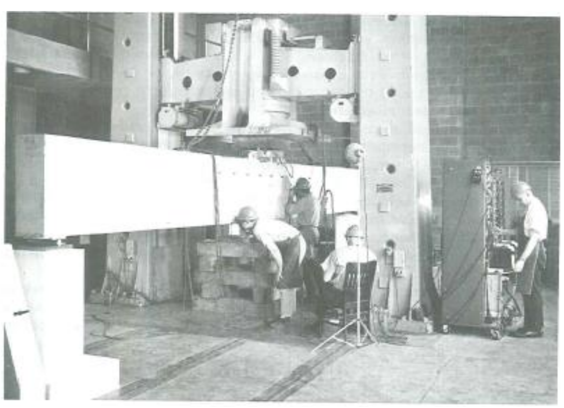


Illustration 6. Test arrangement for beams, Corley

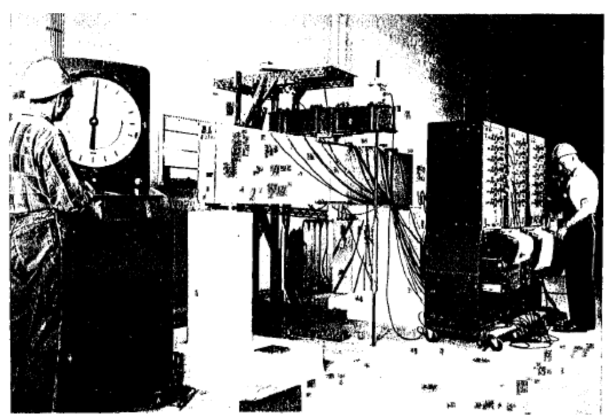


Illustration 7. Typical test arrangement, Mattock

Experimental trials with the following configuration were searched.

General: Beams simply supported subject to simple bending.

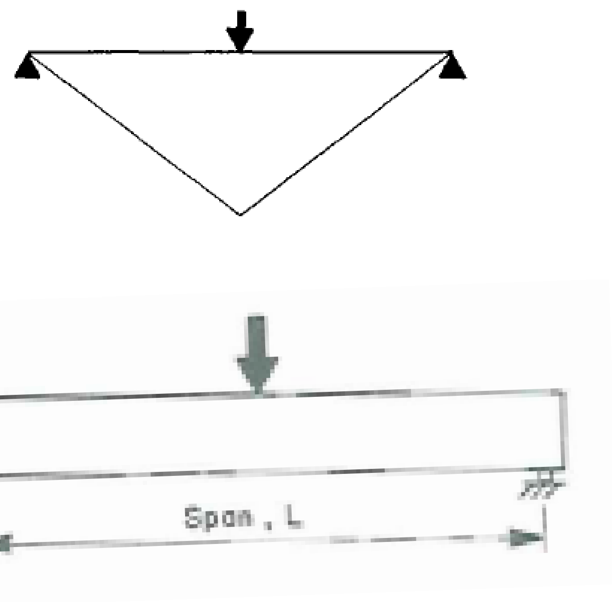


Illustration 8. Simply supported beam

Geometrical: Rectangular cross section, most of the cases with a relation high to depth equal to two.

Structural configuration: All the beams tested had double reinforcement longitudinal bars and transversal reinforcement bars. All the steel used present different strength and were tested for each experiment to determine their strength value.

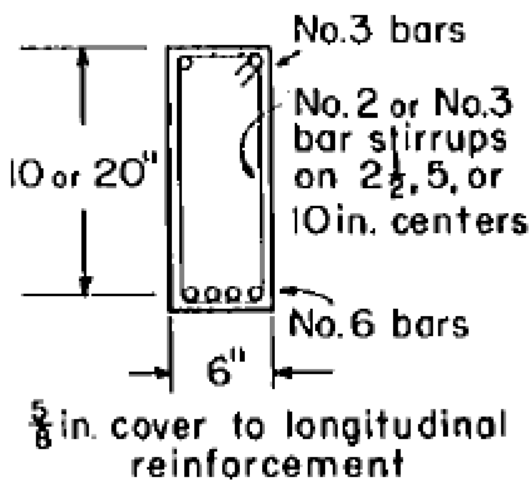


Illustration 9. Mattock cross section a steel configuration.

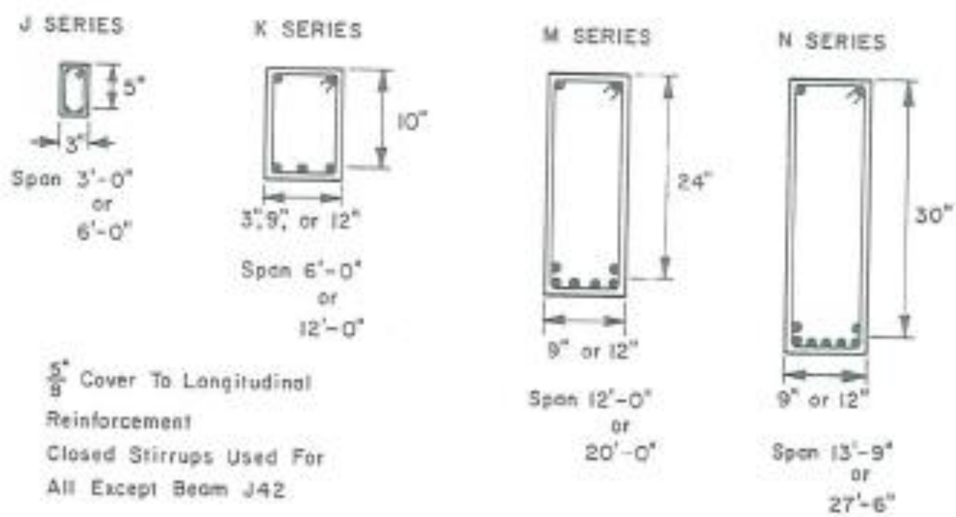


Illustration 10. Corley. Beam test Cross section and steel bars configuration

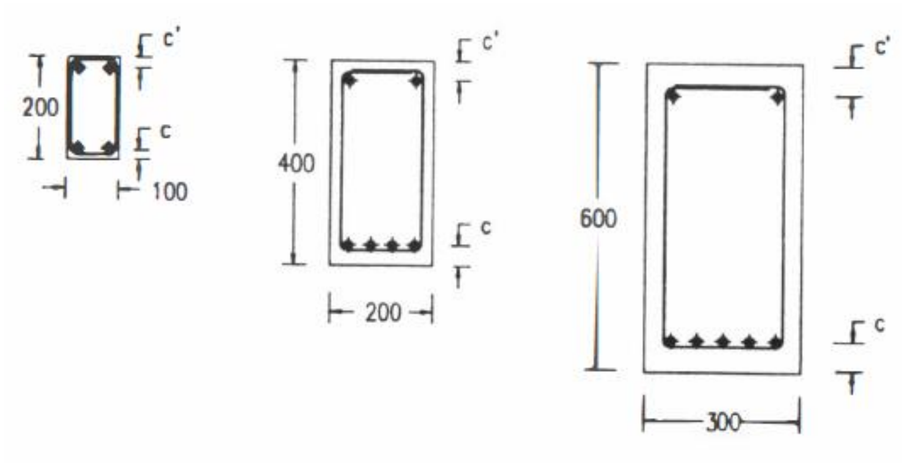


Illustration 11. Bosco Debernardi Beam test Cross section and steel bars configuration

Loads: The beams were subjected to two different types of load configuration, the first load configuration consisted of a single load on the center of the beam until it failed. The second load configuration consisted of two loads applied 1/3 from the center of the beam until it failed.

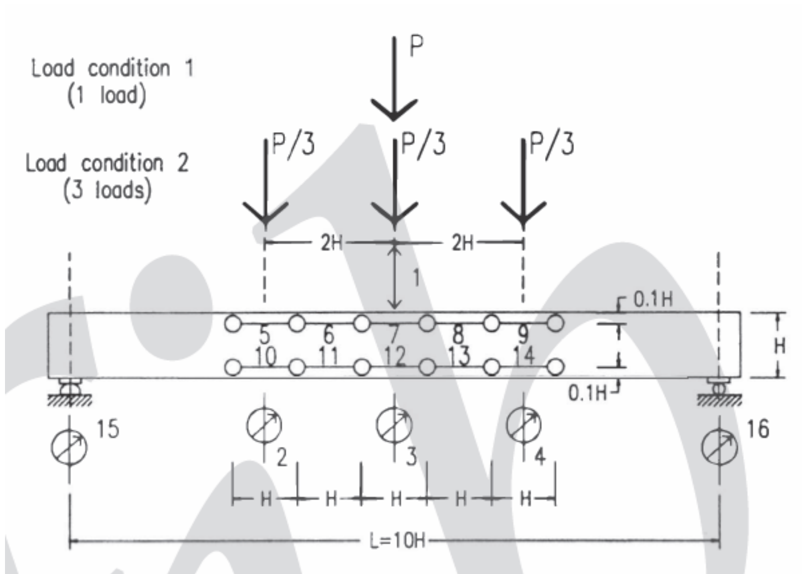


Illustration 12. Load configuration (BoscoDebernardi)

3.2. Experimental Recompilation

For this thesis, 5 different researches were used that were developed in past decades, based on the configuration determined in the previous chapter of case studies. In chronologic order the research used are summarized in the table below, for a total of 141 beams tested.

Principal Researcher	Name of the Paper	Year	Number of Beams tested
Mattock	Rotational capacity of hinging regions in reinforced concrete beams	1965	35
Corley	Rotational Capacity of RC Beams	1966	40
Bosco, Debernardi	Influence of some basic parameters on the plastic rotation of reinforced concrete elements	1993	42
Debernardi	On Evaluation of Rotation Cpacity for Reinforced Concrete Beams	2002	20
Kwak	Simplified monotonic moment–curvature relation considering fixed-end rotation and axial force effect	2007	4
TOTAL			**141**

Table 5. Summarized tested beams.

3.3. Data Base

With all the information collected from the papers two data base were created. One that contains all the input information of the beams tested such the geometrical characteristic of the beam, the mechanical data of the concrete and steel used, the input data needed to develop Mander Model and at last the shear interaction information. All the input information needed is summarized in the table below and the contain of all the data base is in the annexes A of this thesis.

INPUT SECTION											
									Lineas adicionales de refuerzo		
NOMBRE ENSAYO	Section	B	H	L	d	d'	As (mm2)	As' (mm2)	As1 (mm2)	As2 (mm2)	As3 (mm2)
d1	d2	d3	s (mm)	ϕt,v	ϕt,h	Nt,v	Nt,h	rho	rho'		

CONCRETE						
fck - f´c	fct	η	λ	Ec	ecu	ecy

CONCRETE CONFINED CORE MANDER				CONCRETE CONFINED CORE EC			
fcc	eucc	fcc/fc	θ_p	fcc	eucc	fcc/fc	θ_p

STEEL														
fy	esmax	Es	n	Scrm	w*	Lp	Fi	rec	Acef	rho_ef	fy_As'	fy_Stirrups	es_max'	es_maxStirrups

LOAD INPUTS					
AXIAL LOAD	SHEAR INTERACTION				
f_axil	a/d	M/V	θmax	cot θ_{max}	Cycling Load

Table 6. Summarized input info

4

4. Modelling

4.1. Used Program

The Mander and EC models were developed on a spreadsheet in Excel software. This spreadsheet was developed by Professor Bairan and modified in some way by my to be applicable to this thesis. The spreadsheet will be attached digitally but in this section it will be shown how the spreadsheet works based on a single case study. All the results obtained were collected in the database explained in previous chapters. This spreadsheet, with a code developed in VBE, both your input information and its results are automatically stored in the databases already discussed, with this all the diagrams that the program shows for any type of beam (included in this thesis) can be analyzed by just calling it. The beam we select for the explanation of the spreadsheet is the A1T1 of Debernardi paper. Is important to keep in mind that the spreadsheet is in Spanish.

CALCULO DEL DIAGRAMA MOMENTO CURVATURA BILINEAL / CUATRILINEAL
J. M. Bairan (UPC)

NOM ENSAYO		BOSCO DEBERNARDI						
DATOS:	SECCION	T1A1			MATERIALES			
		T1A1						
	B=	100,0 mm	L=	2000,0 mm	Hormigón			
	H=	200,0 mm			fck=f´c=	27,7 MPa	fct=	3,0 MPa
	d=	176,0 mm			η=	1,0		
	d'=	22,0 mm			λ=	0,80		
	As=	113,1 mm2	ρ=	0,64%	Ec=	22000 MPa	27954,86773	
	As´=	50,3 mm2	ρ'=	0,29%	ecu=	0,004		
	Capas adicionales	**Area**	**d**		ecy=	0,0015		
	As1	0,0	0		Hormigón núcleo confinado:			
	As2	0,0	0		fcc=	28,58 MPa	fcc/fc	1,032
Tabla	As3	0,0	0		eucc=	0,0224		5,602857
	Confinamiento				Acero:	T	C	Mander
Calcular	ϕt,v	6,0 mm	Nt,v	2	fyk=fy=	587,0 MPa	587,0 MPa	
	ϕt,h	6,0 mm	Nt,h	2	esmax=	0,07	0,07	
Imprimir Resultado	st	150 mm			Es=	200000 MPa	200000 MPa	
	fyt	587 MPa	est,max	0,07	n=	9,09	9,09	
					Scrm=	158,0 mm	Fi=	12 mm
Imprimir EC	a/d=	5,000			w*=	2,0 mm	rec=	16,0 mm
	F_axil=	1,00E-08 N	OK!		Lp=	194 mm	Acef=	5742
	M/V=	880,0 mm			rot_p=	0,104	rho_ef=	0,020
	θmax:	15,95 º						
	cot θ_max	3,50						
11 multiplier for cyclic loading:		2,00						

Table 7. Spreadsheet developed by Bairan

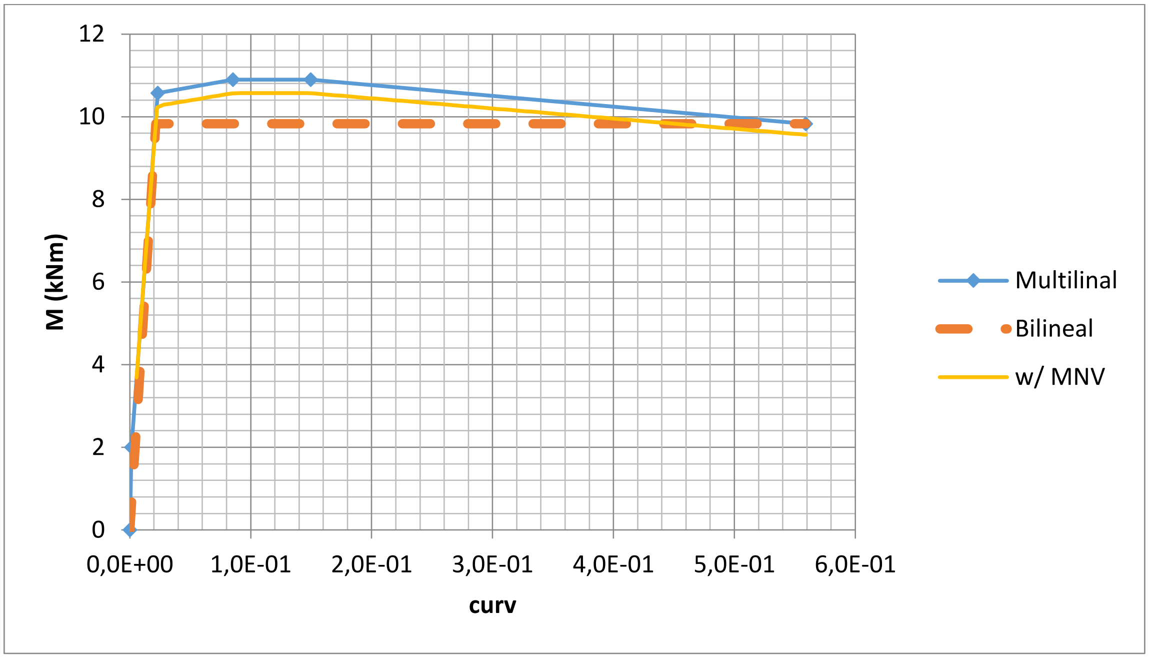
This is the format of the spreadsheet to introduce all the input data.

As you can see, where the name Mander is shown, you can select both Mander and Eurocode to be developed. Once you introduce all the information you need you can calculate the curvature, moments and so on of the beam through the bottom “calcular”

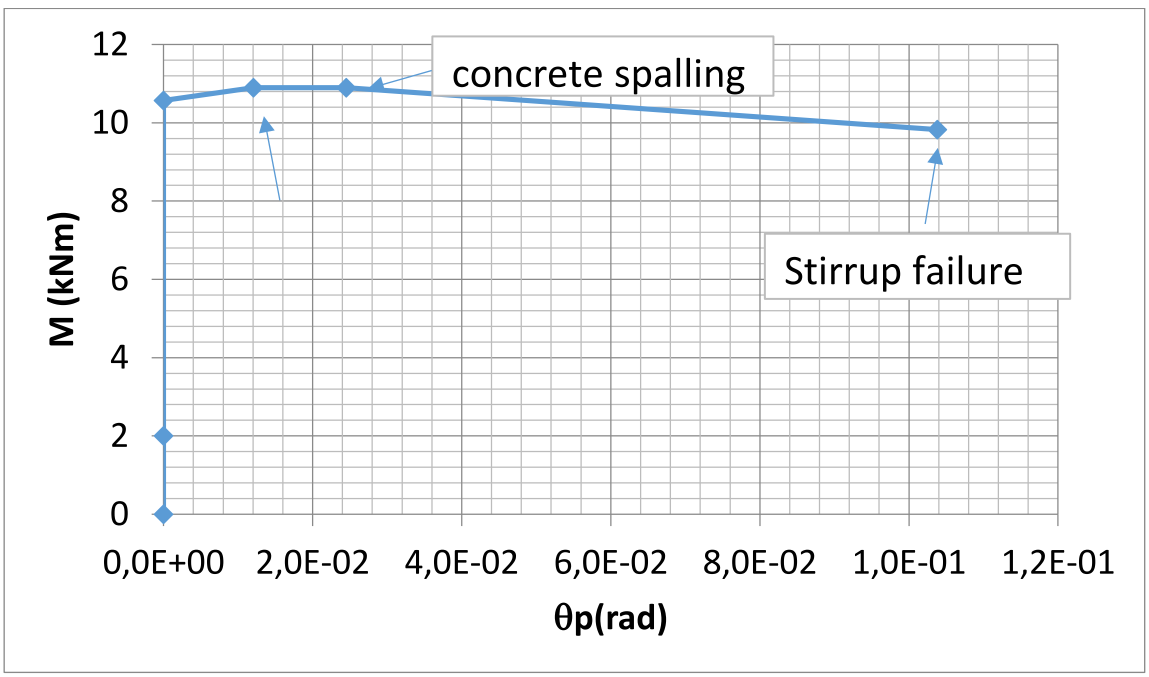
The results are shown below:

	curv	M	μ	μ'	curv	M	μ'
Daño local en elemento	0,00E+00	0,0	0,00	0,00	0,00E+00	0,0	0,00
Fisuración	1,36E-03	2,0	0,06	0,06	2,15E-02	9,8	1,00
Plastificación	2,31E-02	10,6	1,00	1,08	5,59E-01	9,8	26,03
Ancho fisura residual	8,54E-02	10,9	3,70	3,98			
Pérdida Recubrimiento	1,50E-01	10,9	6,48	6,96			
Rotura sección	5,59E-01	9,8	24,21	26,03			

Table 8. Result of the spreadsheet

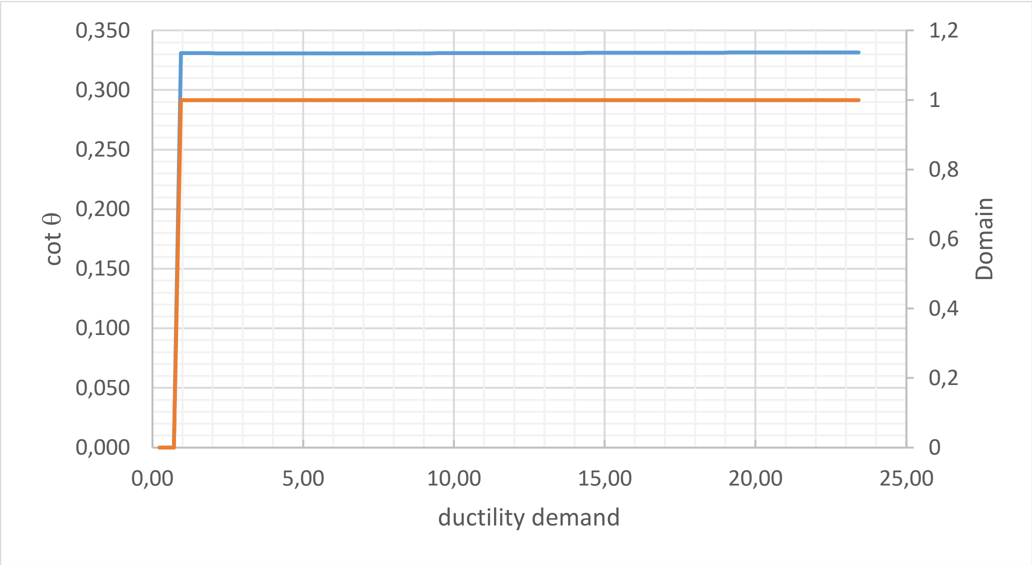


Graphic 17. Moment Curvature beam T1A1



Graphic 18. Moment curvature graphic (radians)

So the results are shown in a numeric way as table 8 and in a graphic way as Graphic 17 and 18. Even more the ductility capacity is presented too as shown below.



Graphic 19. Ductility capacity

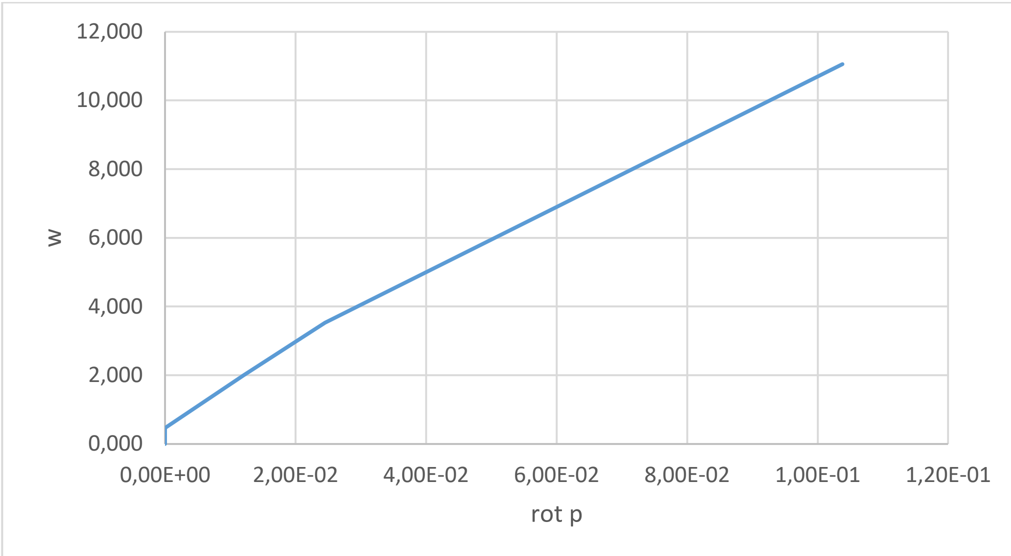
.

In the same way the program is able to graphic the rotation of the beam versus the distance between the stirrups, in other words the rotation dependence of the confinement.

Even more, the program is capable of introduce the shear effect in the beam, but shear effect goes beyond the scope of this thesis.

As it is explained before, all the results obtained are summarized in a second data base that can be consult in the Annexes B.

All the results and indeed the different graphic show above for all the beams collected in this thesis are available to observe and study



Graphic 20. Rotation capacity in term of spacing of stirrups

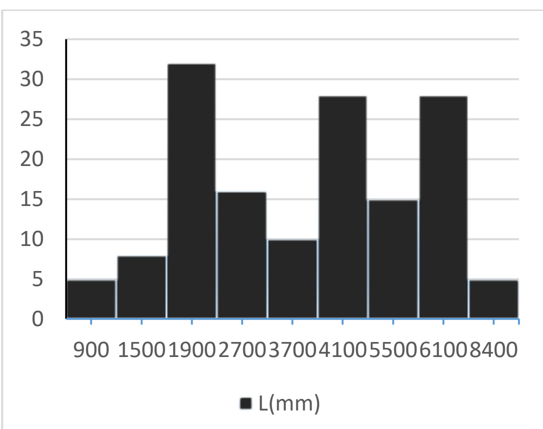
As it is explained before, all the results obtained are summarized in a second data base that can be consult in the Annexes B.

5

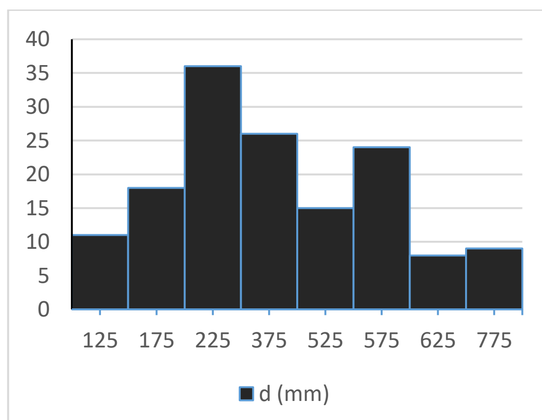
5. Results of Database and Modelling

5.1. Histograms

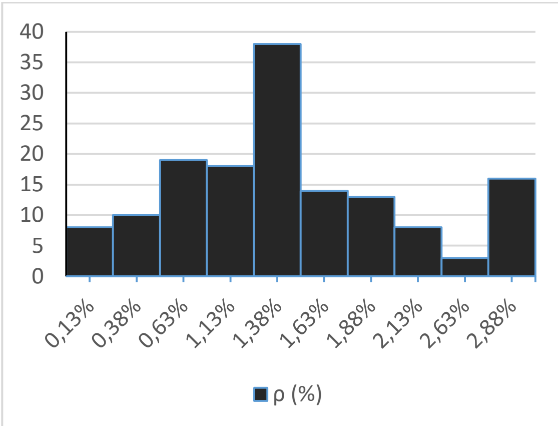
The next graphics are the distribution histograms for some characteristics and results for all the beams studied.



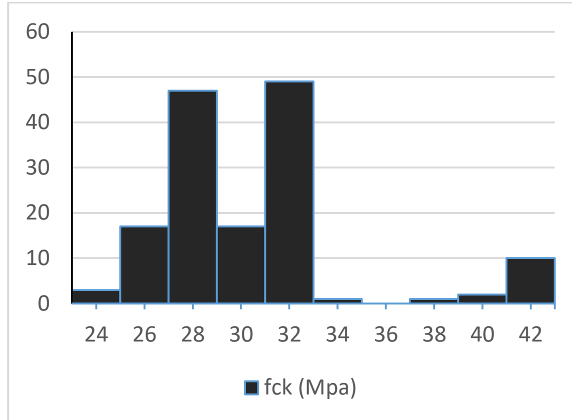
Graphic 21.Histograms Length



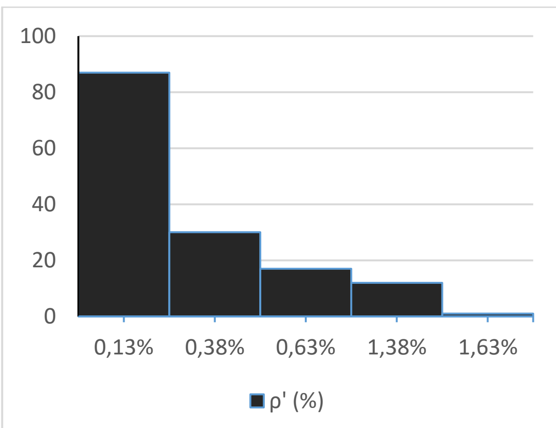
Graphic 22. Effective high Histogram



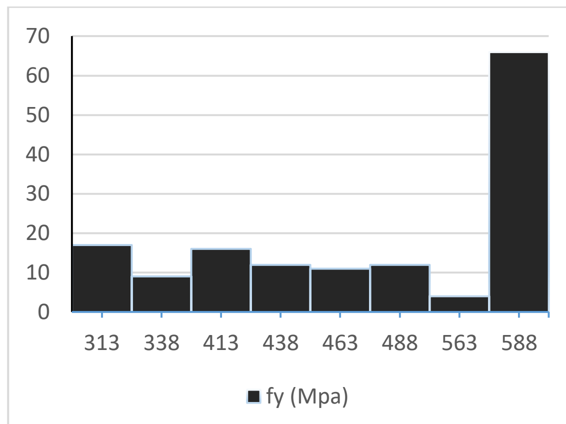
Graphic 23. Histograms Steel quantity.



Graphic 25. Concrete Strength Histogram.



Graphic 24. Quantity of compression steel Histogram



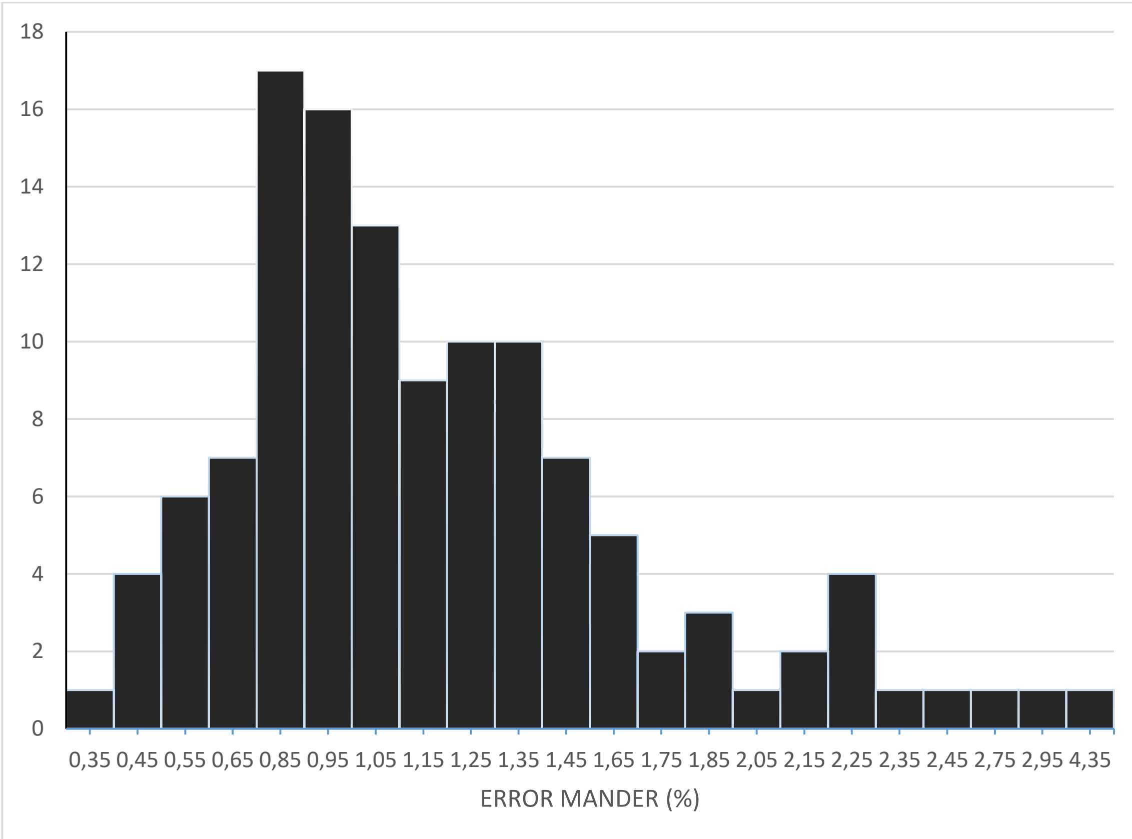
Graphic 26. Steel strength Histogram

The beams can be grouped in terms of different mechanic or geometrical characteristics. It can be observed for example that most of samples have a steel yield strength (fy) above 580 MPA, in the same way the concrete yield strength (fck) of most of the samples are between 25 and 32 Mpa. The amount of reinforcement in the tensile face in most of the arrangements is between 0.5% and 2%.

That is the reason why the data base is so important, because with all the input information and the results shown below you can begin to play with the data, it means for example, we can analyze the influence of the reinforcement quantity in the rotation capacity of the beams or the influence of the strength of the materials in the results. Could be of interest too, the behavior of the beams with the same amount of reinforcement, as the rotational capacity in terms of the effective depth for a gruop of beams with the same ρ. The scope for this thesis is not to analyze that but find a coefficient for minimize the error that is why this is not done in this paper.

5.2. Rotational Capacity Results

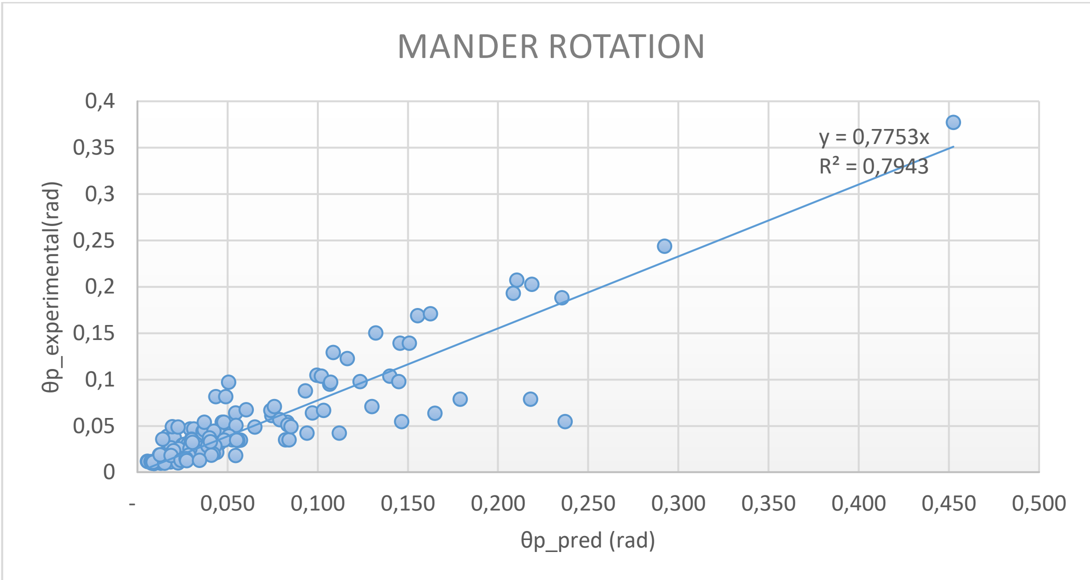
Once the model is run, we obtain all the values for the rotational capacities for the different beams, this results are compare we the ones obtain in an experimental way, dividing the experimental value in the model obtained value. The error is around 0.8% and 1.4%, it means a very acceptable error, taking onto account that the most of the datat is arpund 1% of error, in other terms, cero error. This error is plotted in a histogram as follows. All the result obtained in the measured of the experiments and the ones obtained through the model are shown in Annexes B.



Graphic 27. Mander error Histogram

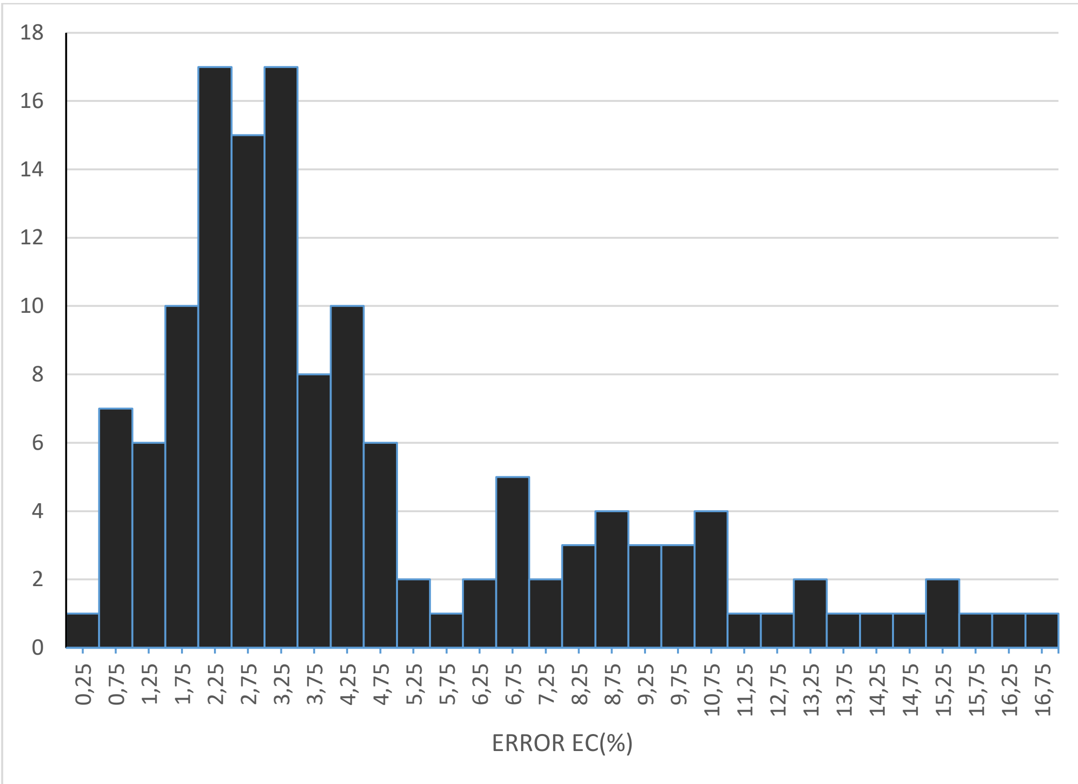
At a first sight if compared with Graphic 15 (Lognormal distribution) for a lognormal distribution with sigma = 0.5 it can be observed the similarity between them, it means that the use of a lognormal distribution fit in an accuracy way the error behavior of the error's model.

The rotations results are plotted against the results collected at the experiments, the results are shown below. We can observe a quite acceptable distribution of the sample, that by adding a trend line (starting from the zero axis) we found a dispersion close to the trend line.



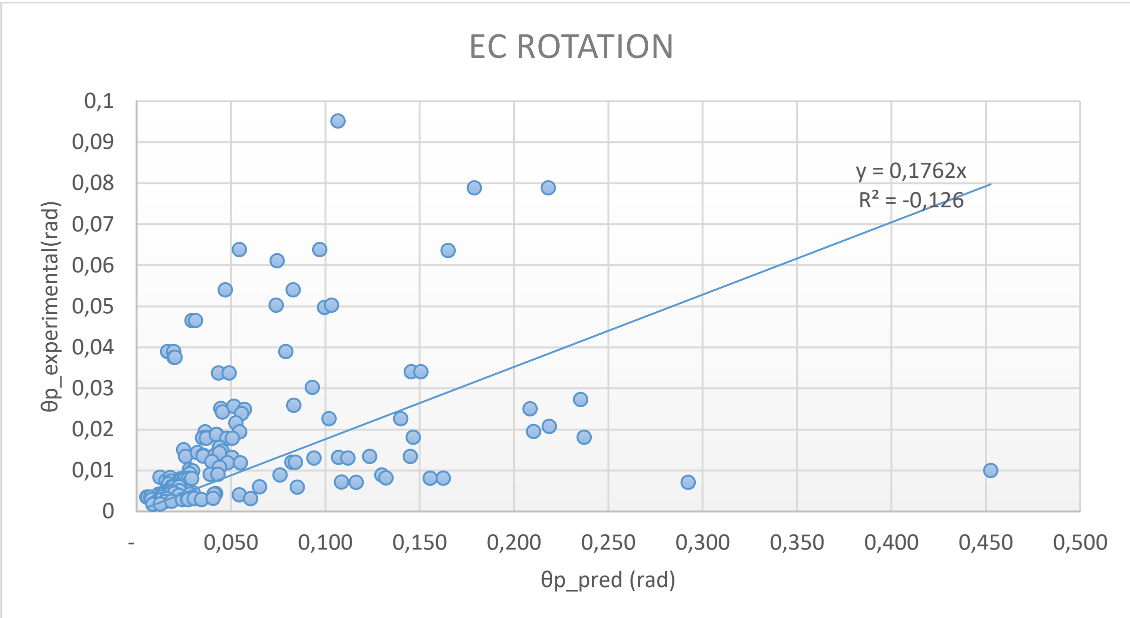
Graphic 28. Comparison of calculated and measured rotations for Mander model.

For the EuroCode model, it can be seen the same kind of lognormal distribution in the error but with a big difference, the error in the Eurocode is quite big. Most of the measured beams present an error between 1,5 and 4,5%, that means 1,5 to 4 times the value measured. Is important to highlight that this error is in the side of the safety because is above 1%, so a first conclusion may arise when we realize that the values given by the EC method are much conserved.

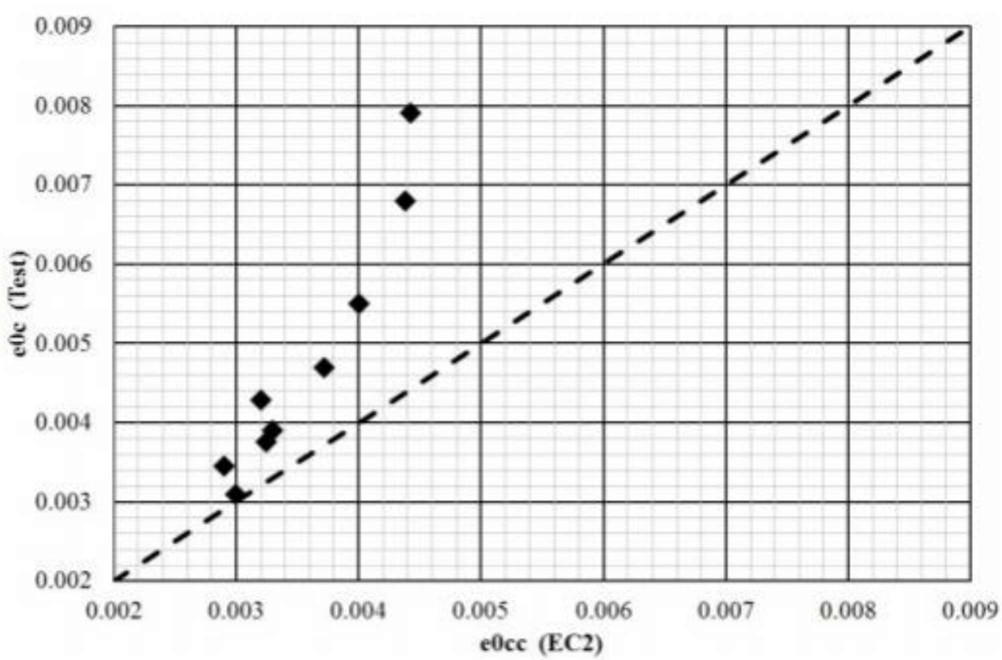


Graphic 29. EC error Histogram

In the same way it is observed that the values present a wide dispersion with respect to the measured values, finding the majority of data above the trend line, off Corse, as we said, are very conservative values. If we observe other studies developed with relation in the subject, like for example, the one of (Bairan, Moreno, and Peguero 2015), we can observe a similarity of data correlation as present in Graphic 31.



Graphic 30. Comparison between measured and calculated rotation.



Graphic 31. Comparison between experimental and predicted peak confined strain. (Bairan 2015)

This graphic show how the maximum strain measured in the experiments versus the ones obtained through the Eurocode model are above the trend line, which means this model is in some way conservative. In the other hand this kind of studies allows to corroborate the quality of our results and the accuracy implementation of the model.

6

6. Analysis of Results

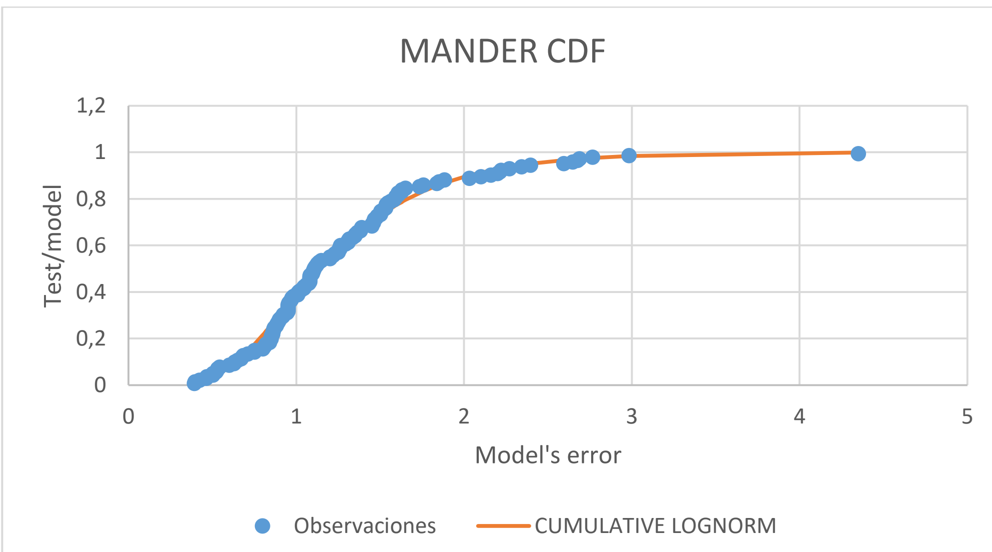
In the Annexes B all the results of the rotational capacity of the beams tested are shown. In the same way in that annexes the error is presented.

	MANDER	EC
Median	1,261	5,246
Coefficient of variantion	0,473	0,985
Standard Deviation	0,597	5,170

Table 9. Probabilistic Values for Both Methods

The error median for the Mander method is 1.26 which means an acceptable error but in the not safety side, this conclusion can be deducted because the standard deviation is below one. In the other hand results obtain by the EC shows a median extremely high that means far results from experimental ones, with a standard deviation close to 1. This results tell us that the EC is in the safety side but without optimal results.

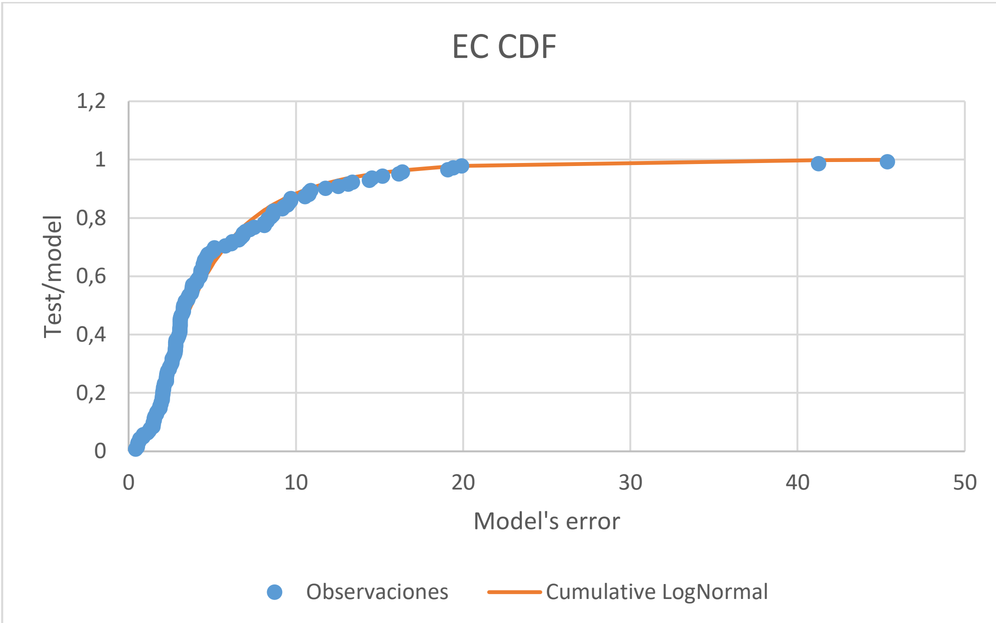
Once the error for each beam is obtained, we proceed to calculate the values for stablish a lognormal distribution. As explained in Chapter 2, the values obtained are the *pdf* (probability density function) and the *cdf* (cumulative density distribution) for the error of each beam. The observed *cdf* results must fit the theoretical *cdf* that is result of the number of the test (the order of each) divided by the amount of beams tested. In the graphic below it is presented both theoretical and lognormal distribution for both methods. The results fit adequatly for both methods.



Graphic 32. Cumulative Density Function

The orange line represents the theorical cumulative distribution, and the blue dot represent the observations. It can be seen that the observations fit well the lognormal distribution, it means that the probabilistic method use is consistent and serves for the scope and pretensions of this thesis

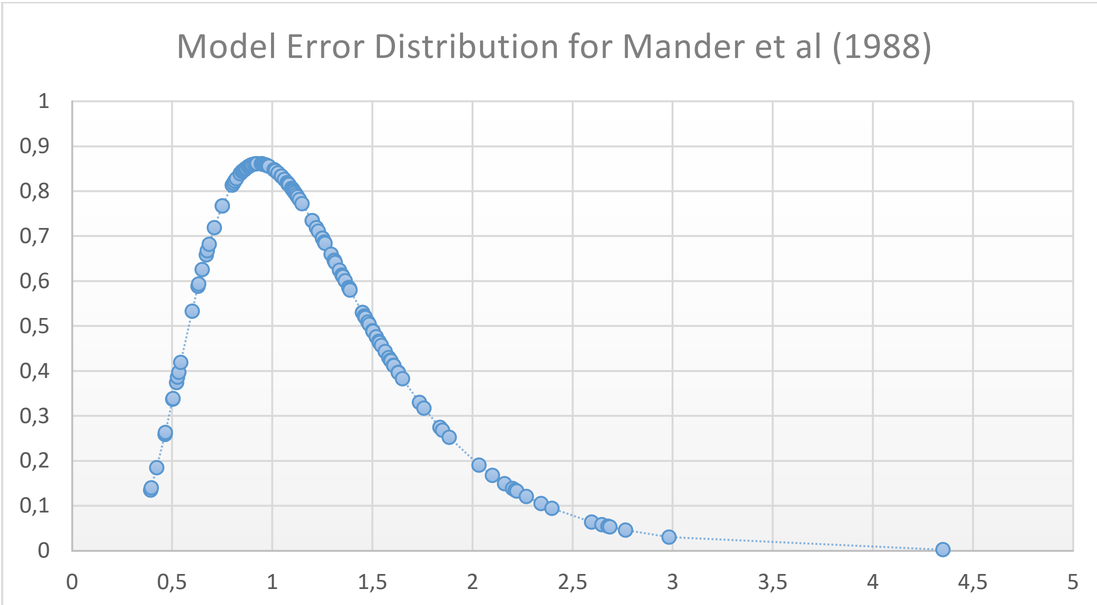
In the other hand for EC method we have the charter below:



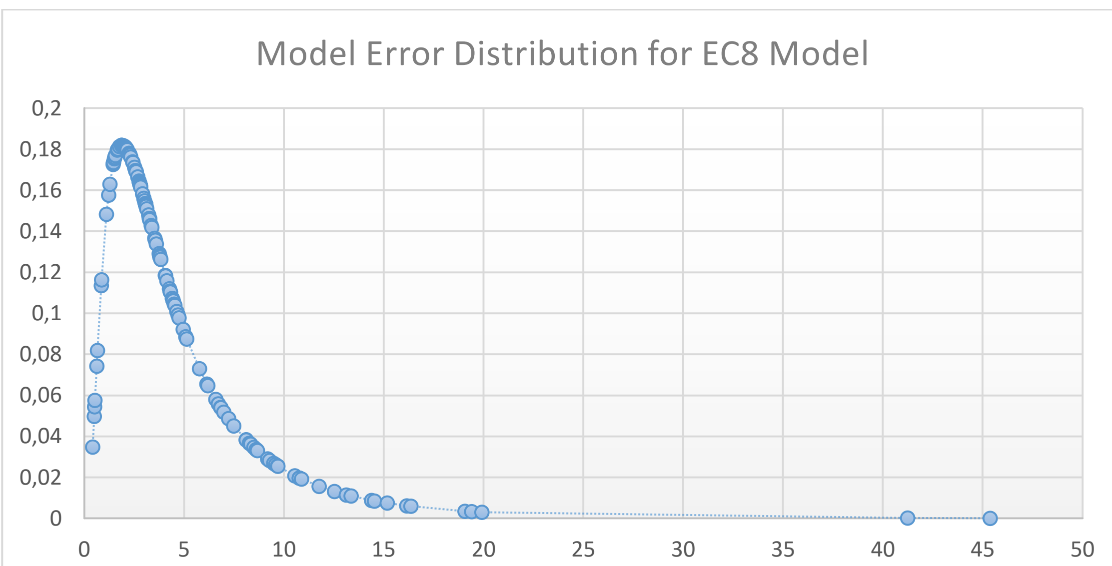
Graphic 33. Cumulative density Function

Similarly, results of the theoretical and observed data fit well, corroborating the appropriate use of the probabilistic method for the scope of the thesis.

Once it is known the probabilistic function used serves, we proceed to find the lognormal density distribution, shown in the next graphics.



Graphic 34. Probability density Function Lognormal for Mander method.



Graphic 35. Probability density Function Lognormal for EC method.

From the lognormal distribution it can be obtained the safety factor coefficient for both methods we are looking for, as explained in chapter 2.

Different values for the reliability index (β) were taken following Eurocode recommendations values, it means that different safety factor coefficients will be found.

This reliability index values were taken following a probability of fail (Pf) given by the C.1 table of the Eurocode (EN 1990. AEN/140 2003) as it is shown below.

Reliability index and the safety factor coefficient were obtained using the equations (28) and (29).

Pf	β	$\gamma_{R\ (Mander)}$	$\gamma_{R\ (EC)}$
1,00E-01	1,28	1,287	0,523
1,00E-02	2,32	1,909	1,187
1,00E-03	3,09	2,554	2,178
1,00E-04	3,72	3,242	3,580
1,00E-05	4,27	3,993	5,523
1,00E-06	4,75	4,789	8,063
1,00E-07	5,20	5,678	11,497

Table 10. Recommended safety factors for rotation capacity for different reliability indexes.

It is important to keep in mind that the proposed equation for the safety factor (equation 29) is refer to medium values of the error found, so in this case (table 10) all the coefficients found are obtained with the medium values but not with characteristic ones.

7

7. Conclusions

7.1. Physical observations and modelling review

- It is necessary to keep in mind that all experiments have several types of errors, either by the prescription of the devices in which the rotation of the beams were measured, the human errors in the use of devices, the manner the data was collected and/or the influence of environmental issues. In the same way the models can present analytical errors. All this considerations may induce to minimal errors in the trials and results. It is important to keep in mind that all the measured instruments by the researchers were different, and the error of each is not taking into account.
- The recompilation of almost 150 specimens for rectangular beams is statistical significant, but would be never enough. More tested trials should be collect. This

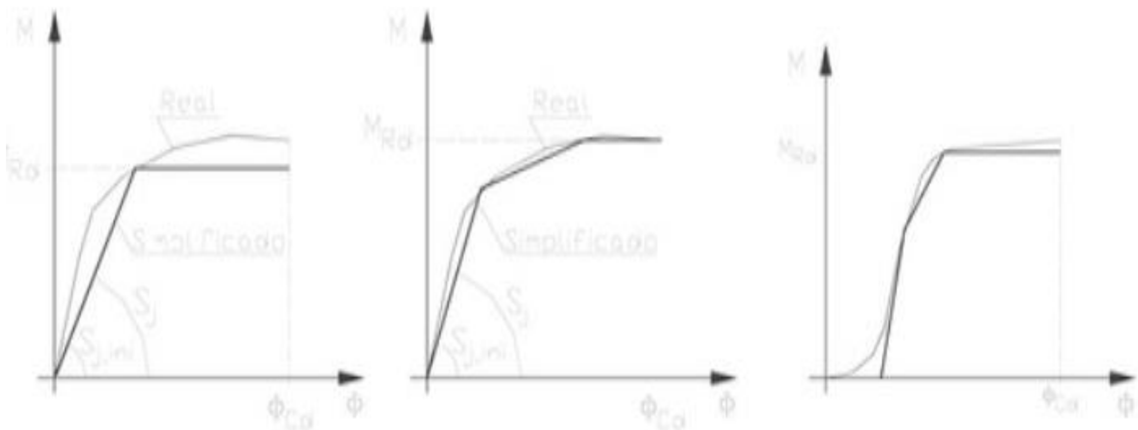
is because the larger is the data collected the higher is the accuracy of the results. (Cervenka 2006)

- The calculus sheet developed by prof. Bairan and modify for this thesis present adequately and solid results, close to the ones obtained by experimental trials.

7.2. Safety Factor Review

- The safety factor coefficients obtained, shows significant variance depending on the probability of failure used, probabilities given by the Eurocode.
- A high value found for standard deviation caused the safety factor coefficient values to vary fast.
- Mander methods is way better in accuracy terms than the one used by the EuroCode but is not in the safe side. It use depends of the designer and must include the coefficients obtained.
- Mean error in Mander method is equal to 1.42 which is acceptable, in the other hand EC shows mean error result upper than 5, meaning 5 times the real rotational measured values.
- The Mander method, being much more optimal and representing in a better way the true behavior of the confined concrete and the generated plastic hinges, represents a saving in terms of the economic cost of the design
- In the other hand the method for the confined concrete propose by the EC is not precise although it is on the security side, in fact, this method is too conservative.
- For this researcher one of the most important result is the well behavior of Mander method and its approval, of course, with this safety factor, in the design of buildings under seismic loads.
- It is important to keep in mind that most of the research used for this thesis deals with certain simplifications in its development, such as the use of only three moments for the development of curvature moment curve, for example, Mattock does not take into account the moments of cracking on the beams that can induce

small errors. The simplification in the data collection is very useful for their use but it can generate not accurate predictions. In the graphic below it can be seen the simplification used by some researchers and the real behavior of the curve.



Graphic 36. Simplification of the moment curvature curve. (Mattock)

- The Mander method presented a greater homogeneous values of the variable, with a coefficient of variation lower than 0.5. The EC method, in the other hand, present heterogeneous values of the variables (the error) with a coefficient of variation of almost one (1.0).
- As presented in the histograms in chapter 5, the amount of longitudinal reinforcement used was around 0.13% and 2.9% but no influence of the amount of steel used in the rotational capacity of the beams is found
- What we did find is that when the amount of longitudinal reinforcement with the amount of transverse reinforcement is high there are greater rotational capacities in the beams.

7.3. Future Considerations

- Some data collected was not useful because the required information was not complete, for example some of the beams tested by Mattock doesn't present the measured rotational value, the same happen in Debernardi's experiments. It is recommended to find the complete thesis of the experiments where the values are shown.
- For future research it is recommend to repeat the study considering the shear forces on the beams and their influence on the rotation.
- The plastic length directly influences the beam's rotation capacity, since, as we saw in chapter 3, the capacity of rotation is given by the curvature by the plastic length.
- The formula used for the plastic length, as explained in chapter 3, was the one given by the EC, some it is recommended to use other plastic length formulas proposed by different researchers.
- Another factor that should be taken into account for future research is the size effect on the beams, since different investigations have shown that there is an influence of the size effect on the capacity of the beams due to the propagation of the cracks.
- In the group of investigation at the UPC there are some other models developed that include the size effect and the shear forces on the beams that can be used in this research.
- It is necessary to collect experiments of the same nature but with different geometrical characteristics (different cross section areas), not only rectangular, as was the case in the current thesis. Biskins (Biskinis 2007) for example, collected more than 2000 specimens of different beams failed in different experiments in his PhD thesis, but he did not analyze the rotational capacity of the beams. Future master students can based their thesis in Biskins collect and the current study to

develop coefficients for the other types of beams and to achieve a single general coefficient that can be used for all types of beams.

- In the same way, the analysis of the plastic hinges can be done through different structural types, to analyze its behavior not from the perspective of the element (beam or column) but from the structure.

8. References

ACI. 1985. *ACI 318-33, Building Code Requirements for Reinforced Concrete*.

Bairán García, Jesús Miguel. 2007. "Proyecto de Estructuras de Hormigón Armado Con Armaduras de Alta Ductilidad." *Tesina*: 135.

Bairan, J, R Moreno, and J Peguero. 2015. "Seismic Behavior of Medium and High Strength Concrete Buildings." *The open civil engineering journal* 9(Suppl. 1, M9): 308–20.

Biskinis, Dionysis. 2007. "Resistance and Deformation Capacity of Concrete Members with or without Retrofitting." *Auth*.

Branson, D.E., and M.L. Christiason. 1971. "Time Dependent Concrete Properties Related To Design-Strength and Elastic Properties, Creep, and Shrinkage." *ACI Structural Journal*.

Cervenka, V. 2006. "Probabilistic Estimate of Global Safety Factor – Comparison of Safety Formats for Design Based on Non-Linear Analysis." *Research Gate*: 1–15.

EHE-08. 2010. "Code on Structural Concrete." : 556.

EN 1990. AEN/140, Comité Técnico. 2003. *Eurocode. Basis of Structural Design. UNE EN 1990*.

Evans, Hastings, and Peacock. 2000. *Statistical Distributions*.

Gerstle, K. H. 1978. "Strength of Concrete Under Multiaxial Stress States." *ACI Special Publications* SP-55.

Kent, D.C., and R. Park. 1971. "Flexural Members with Confined Concrete." *Journal of the Structural Division, Proc. of the American Society of Civil Engineers* (97): 1969–

90.

Kupfer, H., and H. K. Hilsdorf. 1969. “Behavior of Concrete under Biaxial Stresses.” *ACI Structural Journal* 66.

Mander, J. B., and M. J. N. Priestley. 1989. “Theoretical Stress-Strain Model for Confined Concrete.” *ASCE Journal of Structural Engeneering* 114(8).

Mander, J. B., M. J. N Priestley, and R Park. 1984. *Seismic Design of Bridge Piers*.

Nilson, Arthur H. 2008. *Design of Concrete Structures*. 14th ed.

Park, R., and T. Paulay. 1991. *Estructuras de Concreto Reforzado*.

Razvi, Salim, and Murat Saatcioglu. 1992. “CONFINEMENT MODEL FOR HIGH-STRENGTH CONCRETE.” *Journal of structural* ... 125(1): 10–18. http://ascelibrary.org/doi/abs/10.1061/(ASCE)0733-9445(1999)125:1(10).

Richart, F. E., and A Brandtzaeg. 1928. “A Study of the Failure of Concrete under Combined Compressive Stress.” *Bulletin 185, University of Illinois* 185.

Sheikh, S.M., and Shamim A. Uzumeri. 1982. “Analytical Model for Concrete Confinement in Tied Columns.” *Journal of the structural division*.

Tasuji, F. O. 1978. “Strees-Strain Response and Fracture of Concrete in Biaxial Loading.” *ACI Structural Journal* 75.

Torrent, R. J. 1979. “The Log-Normal Distribution " A Better Fitness for the Results of Mechanical Testing of Materials.” *Springer Link* 11(64): 349–50.

Zhao, Xuemei, Yu Fei Wu, A. Yt Leung, and Heung Fai Lam. 2011. “Plastic Hinge Length in Reinforced Concrete Flexural Members.” *Procedia Engineering* 14: 1266–74. http://dx.doi.org/10.1016/j.proeng.2011.07.159.

Annexes A

INPUT DATA BASE

INPUT SECTION														
NOMBRE ENSAYO	Section	B	H	L	d	d'	As (mm2)	As' (mm2)	s (mm)	ϕt,v	ϕt,h	Nt,v	Nt,h	rho
DEBERNARDI [May 200	T1A1	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6,00	6	2	2	0,57%
DEBERNARDI [May 200	T1A3	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6	6	2	2	0,565%
DEBERNARDI [May 200	T2A1	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6,00	6	2	2	0,0113095
DEBERNARDI [May 200	T2A3	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6,00	6	2	2	0,0113095
DEBERNARDI [May 200	T3A1	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6,00	6	2	2	0,0169645
DEBERNARDI [May 200	T3A3	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6,00	6	2	2	0,0169645
DEBERNARDI [May 200	T4A1	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6,00	6	2	2	0,00282743
DEBERNARDI [May 200	T4A3	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6,00	6	2	2	0,00282743
DEBERNARDI [May 200	T5A1	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6,00	6	2	2	0,00565487
DEBERNARDI [May 200	T5A3	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6,00	6	2	2	0,00565487
DEBERNARDI [May 200	T6A1	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6,00	6	2	2	0,01130973
DEBERNARDI [May 200	T6A3	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6,00	6	2	2	0,01130973
DEBERNARDI [May 200	T7A1	200,00	400,00	4.000,00	350,00	45,00	1.357,17	157,08	200,00	6,00	6	2	2	0,0169646
DEBERNARDI [May 200	T7A3	200,00	400,00	4.000,00	350,00	45,00	1.357,17	157,08	200,00	6,00	6	2	2	0,0169646
DEBERNARDI [May 200	T8A1	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6,00	6	2	2	0,00125664
DEBERNARDI [May 200	T8A3	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6,00	6	2	2	0,00125664
DEBERNARDI [May 200	T9A1	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6,00	6	2	2	0,00251327
DEBERNARDI [May 200	T9A3	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6,00	6	2	2	0,00251327
DEBERNARDI [May 200	T10A1	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6,00	6	2	2	0,00565487
DEBERNARDI [May 200	T10A3	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6,00	6	2	2	0,00565487
DEBERNARDI [May 200	T11A1	300,00	600,00	6.000,00	565,00	70,00	2.035,76	226,19	150,00	6,00	6	2	2	0,01130978
DEBERNARDI [May 200	T11A3	300,00	600,00	6.000,00	565,00	70,00	2.035,76	226,19	150,00	6	6	2	2	0,01130978
MATTOCK (1965)	A1	152,70	280,00	1.400,00	254,56	25,46	572,56	143,14	127,28	9,5	9,5	2	2	0,01472968
MATTOCK (1965)	A2	152,70	280,00	2.800,00	254,56	25,46	572,56	143,14	127,28	6,36	6,36	2	2	0,01472968
MATTOCK (1965)	A3	152,70	280,00	5.600,00	254,56	25,46	572,56	143,14	127,28	6,36	6,36	2	2	0,01472968
MATTOCK (1965)	A4	152,70	280,00	1.400,00	254,56	25,46	1.145,12	143,14	63,64	9,55	9,55	2	2	0,02945926
MATTOCK (1965)	A5	152,70	280,00	2.800,00	254,56	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,02945926
MATTOCK (1965)	A6	152,70	280,00	5.600,00	254,56	25,46	1.145,12	143,14	127,28	6,36	6,36	2	2	0,02945926
MATTOCK (1965)	B1	152,70	534,58	2.800,00	509,12	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	B2	152,70	534,58	5.600,00	509,12	25,46	1.145,12	143,14	254,56	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	B3	152,70	534,58	2.800,00	509,12	44,55	2.290,00	143,14	63,64	9,55	9,55	2	2	0,02945617
MATTOCK (1965)	B4	152,70	534,58	5.600,00	509,12	44,55	2.290,00	143,14	127,28	9,55	9,55	2	2	0,02945617
MATTOCK (1965)	C1	152,70	280,02	1.400,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	C2	152,70	280,02	2.800,00	254,56	25,46	572,56	143,14	127,28	6,36	6,36	2	2	0,01472963
MATTOCK (1965)	C2A	152,70	280,02	2.750,00	254,56	25,46	572,56	143,14	127,28	6,36	6,36	2	2	0,01472963
MATTOCK (1965)	C2B	152,70	280,02	2.750,00	254,56	25,46	572,56	-	127,28	6,36	6,36	2	2	0,01472963
MATTOCK (1965)	C3	152,70	280,02	5.600,00	254,56	25,46	572,56	143,14	127,28	6,36	6,36	2	2	0,01472963
MATTOCK (1965)	C4	152,70	280,02	1.400,00	254,56	25,46	1.145,12	143,14	63,64	9,5	9,5	2	2	0,02945926
MATTOCK (1965)	C5	152,70	280,02	2.800,00	254,56	25,46	1.145,12	143,14	127,28	9,5	9,5	2	2	0,02945926
MATTOCK (1965)	C5A	152,70	280,02	2.750,00	254,56	25,46	1.145,12	143,14	127,28	9,5	9,5	2	2	0,02945926
MATTOCK (1965)	C5B	152,70	280,02	2.750,00	254,56	25,46	1.145,12	-	127,28	9,5	9,5	2	2	0,02945926
MATTOCK (1965)	C6	152,70	280,02	5.600,00	254,56	25,46	1.145,12	143,14	127,28	6,36	6,36	2	2	0,02945926
MATTOCK (1965)	D1	152,70	534,58	2.800,00	509,12	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	D2	152,70	534,58	5.600,00	509,12	25,46	1.145,12	143,14	254,56	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	D2A	152,70	534,58	5.498,50	509,12	25,46	1.145,12	143,14	254,56	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	D3	152,70	553,67	2.800,00	509,12	44,55	2.290,25	143,14	63,64	9,55	9,55	2	2	0,02945939
MATTOCK (1965)	D4	152,70	553,67	5.600,00	509,12	44,55	2.290,25	143,14	127,28	9,55	9,55	2	2	0,02945939
MATTOCK (1965)	D4A	152,70	553,67	5.498,50	509,12	44,55	2.290,25	143,14	127,28	9,55	9,55	2	2	0,02945939
MATTOCK (1965)	E1	152,70	280,00	1.400,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	E2	152,70	280,00	2.800,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	E3	152,70	280,00	5.600,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	F1	152,70	280,00	1.400,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	F2	152,70	280,00	2.800,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	F3	152,70	280,00	5.600,00	254,56	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	G1	152,70	534,58	2.800,00	509,12	25,46	858,84	143,14	127,28	9,55	9,55	2	2	0,01104722
MATTOCK (1965)	G2	152,70	534,58	5.600,00	509,12	25,46	858,84	143,14	127,28	9,55	9,55	2	2	0,01104722
MATTOCK (1965)	G3	152,70	534,58	2.800,00	509,12	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	G4	152,70	534,58	5.600,00	509,12	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,01472963
MATTOCK (1965)	G5	152,70	534,58	5.600,00	509,12	25,46	572,56	143,14	127,28	9,55	9,55	2	2	0,00736481

Corley (1966)	J1	78,37	152,74	916,42	127,28	25,46	198,81	143,14	63,64	6,36	6,36	2	2	0,01993096
Corley (1966)	J11	76,40	152,74	916,42	127,28	25,46	198,81	143,14	63,64	6,36	6,36	2	2	0,02044489
Corley (1966)	J2	76,40	152,74	1.832,83	127,28	25,46	198,81	143,14	63,64	6,36	6,36	2	2	0,02044489
Corley (1966)	J21	76,40	152,74	1.832,83	127,28	25,46	198,81	143,14	63,64	6,36	6,36	2	2	0,02044489
Corley (1966)	J3	76,40	152,74	916,42	127,28	25,46	198,81	143,14	31,82	6,36	6,36	2	2	0,02044489
Corley (1966)	J4	76,40	152,74	1.832,83	127,28	25,46	254,47	143,14	63,64	6,36	6,36	2	2	0,02616876
Corley (1966)	J41	76,40	152,74	1.832,83	127,28	25,46	254,47	143,14	63,64	6,36	6,36	2	2	0,02616876
Corley (1966)	J42	76,40	152,74	1.832,83	127,28	25,46	254,47	143,14	63,64	6,36	6,36	2	2	0,02616876
Corley (1966)	J5	76,40	152,74	916,42	127,28	25,46	286,28	143,14	31,82	6,36	6,36	2	2	0,02943998
Corley (1966)	J6	76,40	152,74	1.832,83	127,28	25,46	286,28	143,14	63,64	6,36	6,36	2	2	0,02943998
Corley (1966)	J61	76,40	152,74	1.832,83	127,28	25,46	286,28	143,14	63,64	6,36	6,36	2	2	0,02943998
Corley (1966)	K1	76,40	280,00	1.832,83	254,56	25,46	397,61	143,14	127,28	6,36	6,36	2	2	0,02044437
Corley (1966)	K2	76,40	280,00	3.665,66	254,56	25,46	397,61	143,14	127,28	6,36	6,36	2	2	0,02044437
Corley (1966)	K3	76,40	280,00	1.832,83	254,56	25,46	397,61	143,14	63,64	6,36	6,36	2	2	0,02044437
Corley (1966)	K4	76,40	280,00	3.665,66	254,56	25,46	397,61	143,14	127,28	6,36	6,36	2	2	0,02044437
Corley (1966)	K5	229,10	280,00	1.832,83	254,56	25,46	795,23	143,14	127,28	6,36	6,36	2	2	0,0136357
Corley (1966)	K51	229,10	280,00	1.832,83	254,56	25,46	795,23	143,14	127,28	9,55	9,55	2	2	0,0136357
Corley (1966)	K6	229,10	280,00	3.665,66	254,56	25,46	795,23	143,14	127,28	6,36	6,36	2	2	0,0136357
Corley (1966)	K7	229,10	280,00	1.832,83	254,56	25,46	1.145,12	143,14	127,28	9,55	9,55	2	2	0,01963522
Corley (1966)	K8	229,10	280,00	3.665,66	254,56	25,46	1.145,12	143,14	127,28	6,36	6,36	2	2	0,01963522
Corley (1966)	K9	305,47	280,00	1.832,83	254,56	25,46	994,03	143,14	63,64	6,36	6,36	2	2	0,01278323
Corley (1966)	K10	305,47	280,00	3.665,66	254,56	25,46	994,03	143,14	127,28	6,36	6,36	2	2	0,01278323
Corley (1966)	K11	305,47	280,00	1.932,00	254,56	25,46	994,03	143,14	63,64	9,55	9,55	2	2	0,01278323
Corley (1966)	K12	305,47	280,00	3.665,66	254,56	25,46	994,03	143,14	127,28	6,36	6,36	2	2	0,01278323
Corley (1966)	M1	229,10	649,13	3.665,66	610,94	38,18	1.717,69	143,14	305,47	9,55	9,55	2	2	0,01227216
Corley (1966)	M2	229,10	649,13	6.109,44	610,94	38,18	1.717,69	143,14	305,47	9,55	9,55	2	2	0,01227216
Corley (1966)	M3	229,10	649,13	3.665,66	610,94	38,18	2.337,96	143,14	152,74	9,55	9,55	2	2	0,01670373
Corley (1966)	M4	229,10	649,13	6.110,00	610,94	38,18	2.337,96	143,14	305,41	9,55	9,55	2	2	0,01670373
Corley (1966)	M5	305,47	649,13	3.665,66	610,94	38,18	2.290,25	143,14	203,65	9,55	9,55	2	2	0,01227201
Corley (1966)	M6	305,47	649,13	6.110,00	610,94	38,18	2.290,25	143,14	305,47	9,55	9,55	2	2	0,01227201
Corley (1966)	M7	305,47	649,13	3.665,66	610,94	38,18	3.506,94	143,14	203,65	9,55	9,55	2	2	0,01879149
Corley (1966)	M8	305,47	649,13	6.110,00	610,94	38,18	3.506,94	143,14	305,47	9,55	9,55	2	2	0,01879149
Corley (1966)	N1	229,10	801,86	4.200,00	763,68	38,18	2.727,62	143,14	254,56	9,55	9,55	2	2	0,01559004
Corley (1966)	N2	229,10	801,86	8.400,00	763,68	38,18	2.727,62	143,14	381,84	9,55	9,55	2	2	0,01559004
Corley (1966)	N3	229,10	801,86	4.200,00	763,68	38,18	3.053,67	143,14	254,56	12,73	12,73	2	2	0,01745362
Corley (1966)	N4	229,10	801,86	8.400,00	763,68	38,18	3.053,67	143,14	381,84	9,55	9,55	2	2	0,01745362
Corley (1966)	N5	305,50	801,86	4.200,00	763,68	38,18	2.544,72	143,14	381,84	12,73	12,73	2	2	0,0109073
Corley (1966)	N6	305,50	801,86	8.400,00	763,68	38,18	2.544,72	143,14	381,84	12,73	12,73	2	2	0,0109073
Corley (1966)	N7	305,50	801,86	4.200,00	763,68	38,18	4.071,00	55,00	229,10	12,73	12,73	2	2	0,01744932
Corley (1966)	N8	305,50	801,86	8.400,00	763,68	38,18	4.071,00	55,00	381,84	12,73	12,73	2	2	0,01744932
KWAK (2007)	BEAMR6	228,60	406,40	1.589,00	387,30	34,90	1.256,64	1.256,64	100,00	6,36	6,36	2	2	0,01419342
KWAK (2007)	BEAMR4	228,60	406,40	1.589,00	387,30	34,90	1.256,64	603,20	100,00	6,36	6,36	2	2	0,01419342
KWAK (2007)	BEAMS1	152,40	304,80	876,00	254,00	50,80	628,32	628,32	100,00	6,36	6,36	2	2	0,01623163
KWAK (2007)	COLUMN1	152,40	801,86	8.400,00	763,68	38,18	4.071,00	55,00	381,84	12,73	12,73	2	2	0,01744932

BOSCO DEBERNARDI	193_T1A1	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6	6	2	2	0,64%
BOSCO DEBERNARDI	193_T1B1	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6	6	2	2	0,64%
BOSCO DEBERNARDI	193_T1A3	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6	6	2	2	0,64%
BOSCO DEBERNARDI	193_T1B3	100,00	200,00	2.000,00	176,00	22,00	113,10	50,27	150,00	6	6	2	2	0,64%
BOSCO DEBERNARDI	193_T2A1	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6	6	2	2	1,29%
BOSCO DEBERNARDI	193_T2B1	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6	6	2	2	1,29%
BOSCO DEBERNARDI	193_T2A3	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6	6	2	2	1,29%
BOSCO DEBERNARDI	193_T2B3	100,00	200,00	2.000,00	176,00	22,00	226,19	100,53	150,00	6	6	2	2	1,29%
BOSCO DEBERNARDI	193_T3A1	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6	6	2	2	1,93%
BOSCO DEBERNARDI	193_T3B1	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6	6	2	2	1,93%
BOSCO DEBERNARDI	193_T3A3	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6	6	2	2	1,93%
BOSCO DEBERNARDI	193_T3B3	100,00	200,00	2.000,00	176,00	22,00	339,29	100,53	150,00	6	6	2	2	1,93%
BOSCO DEBERNARDI	193_T4A1	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6	6	2	2	0,31%
BOSCO DEBERNARDI	193_T4B1	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6	6	2	2	0,31%
BOSCO DEBERNARDI	193_T4A3	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6	6	2	2	0,31%
BOSCO DEBERNARDI	193_T4B3	200,00	400,00	4.000,00	365,00	45,00	226,19	157,08	200,00	6	6	2	2	0,31%
BOSCO DEBERNARDI	193_T5A1	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6	6	2	2	0,62%
BOSCO DEBERNARDI	193_T5B1	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6	6	2	2	0,62%
BOSCO DEBERNARDI	193_T5A3	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6	6	2	2	0,62%
BOSCO DEBERNARDI	193_T5B3	200,00	400,00	4.000,00	365,00	45,00	452,39	157,08	200,00	6	6	2	2	0,62%
BOSCO DEBERNARDI	193_T6A1	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6	6	2	2	1,26%
BOSCO DEBERNARDI	193_T6B1	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6	6	2	2	1,26%
BOSCO DEBERNARDI	193_T6A3	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6	6	2	2	1,26%
BOSCO DEBERNARDI	193_T6B3	200,00	400,00	4.000,00	360,00	45,00	904,78	157,08	200,00	6	6	2	2	1,26%
BOSCO DEBERNARDI	193_T7A1	200,00	400,00	4.000,00	350,00	45,00	1.357,17	226,19	200,00	6	6	2	2	1,94%
BOSCO DEBERNARDI	193_T7B1	200,00	400,00	4.000,00	350,00	45,00	1.357,17	226,19	200,00	6	6	2	2	1,94%
BOSCO DEBERNARDI	193_T7A3	200,00	400,00	4.000,00	350,00	45,00	1.357,17	226,19	200,00	6	6	2	2	1,94%
BOSCO DEBERNARDI	193_T7B3	200,00	400,00	4.000,00	350,00	45,00	1.357,17	226,19	200,00	6	6	2	2	1,94%
BOSCO DEBERNARDI	193_T8A1	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6	6	2	2	0,13%
BOSCO DEBERNARDI	193_T8B1	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6	6	2	2	0,13%
BOSCO DEBERNARDI	193_T8A3	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6	6	2	2	0,13%
BOSCO DEBERNARDI	193_T8B3	300,00	600,00	6.000,00	565,00	70,00	226,19	226,19	150,00	6	6	2	2	0,13%
BOSCO DEBERNARDI	193_T9A1	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6	6	2	2	0,27%
BOSCO DEBERNARDI	193_T9B1	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6	6	2	2	0,27%
BOSCO DEBERNARDI	193_T9A3	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6	6	2	2	0,27%
BOSCO DEBERNARDI	193_T9B3	300,00	600,00	6.000,00	565,00	70,00	452,39	226,19	150,00	6	6	2	2	0,27%
BOSCO DEBERNARDI	193_T10A1	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6	6	2	2	0,60%
BOSCO DEBERNARDI	193_T10B1	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6	6	2	2	0,60%
BOSCO DEBERNARDI	193_T10A3	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6	6	2	2	0,60%
BOSCO DEBERNARDI	193_T10B3	300,00	600,00	6.000,00	565,00	70,00	1.017,88	226,19	150,00	6	6	2	2	0,60%
BOSCO DEBERNARDI	193_T11A1	300,00	600,00	6.000,00	550,00	70,00	2.035,75	226,19	150,00	6	6	2	2	1,23%
BOSCO DEBERNARDI	193_T11B1	300,00	600,00	6.000,00	550,00	70,00	2.035,75	226,19	150,00	6	6	2	2	1,23%
BOSCO DEBERNARDI	193_T11A3	300,00	600,00	6.000,00	550,00	70,00	2.035,75	226,19	150,00	6	6	2	2	1,23%
BOSCO DEBERNARDI	193_T11B3	300,00	600,00	6.000,00	550,00	70,00	2.035,75	226,19	150,00	6	6	2	2	1,23%

		HORMIGÓN							HORMIGÓN NÚCLEO CONFINADO (MANDER)				HORMIGÓN NÚCLEO CONFINADO (EUROCODIGO)			
NOMBRE ENSAYO	**Section**	**fck - f´c**	**fct**	**η**	**λ**	**Ec**	**ecu**	**ecy**	**fcc**	**eucc**	**fcc/fc**	**θ_p**	**fcc**	**eucc**	**fcc/fc**	**θ_p**
DEBERNARDI [May 200	T1A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,1046	27,6030	0,0230	0,9965	0,1046
DEBERNARDI [May 200	T1A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,1046	27,6030	0,0230	0,9965	0,1046
DEBERNARDI [May 200	T2A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,0703	27,6011	0,0230	0,9964	0,0703
DEBERNARDI [May 200	T2A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,0703	27,6011	0,0230	0,9964	0,0703
DEBERNARDI [May 200	T3A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,0355	27,5997	0,0230	0,9964	0,0355
DEBERNARDI [May 200	T3A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0230	1,0000	0,0355	27,5997	0,0230	0,9964	0,0355
DEBERNARDI [May 200	T4A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0636	27,7000	0,0112	1,0000	0,0636
DEBERNARDI [May 200	T4A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0636	27,7000	0,0112	1,0000	0,0636
DEBERNARDI [May 200	T5A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0423	27,7000	0,0112	1,0000	0,0423
DEBERNARDI [May 200	T5A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0423	27,7000	0,0112	1,0000	0,0423
DEBERNARDI [May 200	T6A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0146	27,7000	0,0112	1,0000	0,0146
DEBERNARDI [May 200	T6A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0146	27,7000	0,0112	1,0000	0,0146
DEBERNARDI [May 200	T7A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0099	27,7000	0,0112	1,0000	0,0099
DEBERNARDI [May 200	T7A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0112	1,0000	0,0099	27,7000	0,0112	1,0000	0,0099
DEBERNARDI [May 200	T8A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0540	27,7000	0,0106	1,0000	0,0540
DEBERNARDI [May 200	T8A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0540	27,7000	0,0106	1,0000	0,0540
DEBERNARDI [May 200	T9A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0569	27,7000	0,0106	1,0000	0,0569
DEBERNARDI [May 200	T9A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0569	27,7000	0,0106	1,0000	0,0569
DEBERNARDI [May 200	T10A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0286	27,7000	0,0106	1,0000	0,0286
DEBERNARDI [May 200	T10A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0286	27,7000	0,0106	1,0000	0,0286
DEBERNARDI [May 200	T11A1	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0109	27,7000	0,0106	1,0000	0,0109
DEBERNARDI [May 200	T11A3	27,7	3	1	0,8	22000	0,004	0,0015	27,7000	0,0106	1,0000	0,0109	27,7000	0,0106	1,0000	0,0109
MATTOCK (1965)	A1	38,2	3,2	1	0,8	30461,0384	0,004	0,0015	39,8963	0,0097	1,0444	0,0346	39,0199	0,0097	1,0215	0,0346
MATTOCK (1965)	A2	42,3	3,2	1	0,8	31335,8201	0,004	0,0015	43,2315	0,0066	1,0220	0,0342	42,6333	0,0066	1,0079	0,0342
MATTOCK (1965)	A3	40,92	3,2	1	0,8	31046,8764	0,004	0,0015	41,8480	0,0067	1,0227	0,0355	41,2563	0,0067	1,0082	0,0355
MATTOCK (1965)	A4	42,85	3,2	1	0,8	31449,505	0,004	0,0015	47,7575	0,0136	1,1145	0,0368	46,4098	0,0136	1,0831	0,0368
MATTOCK (1965)	A5	39,64	3,2	1	0,8	30773,9695	0,004	0,0015	41,3751	0,0094	1,0438	0,0208	40,4734	0,0094	1,0210	0,0208
MATTOCK (1965)	A6	41,09	3,2	1	0,8	31082,7622	0,004	0,0015	42,0407	0,0067	1,0231	0,0138	41,4375	0,0067	1,0085	0,0138
MATTOCK (1965)	B1	42,95	3,2	1	0,8	31470,0868	0,004	0,0015	42,9500	0,0085	1,0000	0,0261	42,9500	0,0085	1,0000	0,0261
MATTOCK (1965)	B2	41,78	3,2	1	0,8	31227,571	0,004	0,0015	41,7800	0,0063	1,0000	0,0222	41,7800	0,0063	1,0000	0,0222
MATTOCK (1965)	B3	42,89	3,2	1	0,8	31457,741	0,004	0,0015	42,8900	0,0181	1,0000	0,0187	42,8900	0,0181	1,0000	0,0187
MATTOCK (1965)	B4	42,82	3,2	1	0,8	31443,3252	0,004	0,0015	42,8200	0,0107	1,0000	0,0101	42,8200	0,0107	1,0000	0,0101
MATTOCK (1965)	C1	27,44	3,2	1	0,8	27886,906	0,004	0,0015	28,9945	0,0119	1,0567	0,0392	28,2740	0,0119	1,0304	0,0392
MATTOCK (1965)	C2	25,99	3,2	1	0,8	27501,6571	0,004	0,0015	26,8805	0,0089	1,0343	0,0304	26,3751	0,0089	1,0148	0,0304
MATTOCK (1965)	C2A	28,54	3,2	1	0,8	28172,2057	0,004	0,0015	29,4049	0,0081	1,0303	0,0307	28,8949	0,0081	1,0124	0,0307
MATTOCK (1965)	C2B	28	3,2	1	0,8	28032,8762	0,004	0,0015	28,8633	0,0082	1,0308	0,0221	28,3569	0,0082	1,0127	0,0221
MATTOCK (1965)	C3	25,58	2,9	1	0,8	27390,7419	0,004	0,0015	26,4039	0,0085	1,0322	0,0283	25,9270	0,0085	1,0136	0,0283
MATTOCK (1965)	C4	25,92	2,9	1	0,8	27482,7838	0,004	0,0015	30,0827	0,0191	1,1606	0,0310	29,4105	0,0191	1,1347	0,0310
MATTOCK (1965)	C5	23,37	2,9	1	0,8	26776,7745	0,004	0,0015	24,8428	0,0129	1,0630	0,0160	24,1971	0,0129	1,0354	0,0160
MATTOCK (1965)	C5A	28,89	2,9	1	0,8	28261,7798	0,004	0,0015	30,5179	0,0117	1,0563	0,0186	29,7614	0,0117	1,0302	0,0186
MATTOCK (1965)	C5B	28,34	2,9	1	0,8	28120,7633	0,004	0,0015	29,9557	0,0118	1,0570	0,0154	29,2092	0,0118	1,0307	0,0154
MATTOCK (1965)	C6	27,37	2,9	1	0,8	27868,5518	0,004	0,0015	28,2735	0,0085	1,0330	0,0116	27,7546	0,0085	1,0141	0,0116
MATTOCK (1965)	D1	26,68	2,9	1	0,8	27868,5518	0,004	0,0015	26,6800	0,0113	1,0000	0,0260	26,6800	0,0113	1,0000	0,0260
MATTOCK (1965)	D2	25,61	2,9	1	0,8	27398,8882	0,004	0,0015	25,6100	0,0077	1,0000	0,0165	25,6100	0,0077	1,0000	0,0165
MATTOCK (1965)	D2A	25,48	2,9	1	0,8	27363,5526	0,004	0,0015	25,4800	0,0079	1,0000	0,0176	25,4800	0,0079	1,0000	0,0176
MATTOCK (1965)	D3	25,96	2,9	1	0,8	27493,5718	0,004	0,0015	25,9600	0,0262	1,0000	0,0321	25,9600	0,0262	1,0000	0,0321
MATTOCK (1965)	D4	26,89	2,9	1	0,8	27742,0371	0,004	0,0015	26,8900	0,0141	1,0000	0,0098	26,8900	0,0141	1,0000	0,0098
MATTOCK (1965)	D4A	27,65	2,9	1	0,8	27941,8239	0,004	0,0015	27,6500	0,0148	1,0000	0,0104	27,6500	0,0148	1,0000	0,0104
MATTOCK (1965)	E1	28	2,9	1	0,8	28032,8762	0,004	0,0015	29,9861	0,0147	1,0709	0,0445	29,1733	0,0147	1,0419	0,0445
MATTOCK (1965)	E2	28	2,9	1	0,8	28032,8762	0,004	0,0015	29,9803	0,0147	1,0707	0,0457	29,1684	0,0147	1,0417	0,0457
MATTOCK (1965)	E3	29,79	2,9	1	0,8	28489,5396	0,004	0,0015	31,8636	0,0145	1,0696	0,0444	31,0051	0,0145	1,0408	0,0444
MATTOCK (1965)	F1	41,23	2,9	1	0,8	31112,2529	0,004	0,0015	43,4280	0,0113	1,0533	0,0393	42,3788	0,0113	1,0279	0,0393
MATTOCK (1965)	F2	41,37	2,9	1	0,8	31141,6878	0,004	0,0015	43,6069	0,0114	1,0541	0,0405	42,5463	0,0114	1,0284	0,0405
MATTOCK (1965)	F3	42,85	2,9	1	0,8	31449,505	0,004	0,0015	45,1719	0,0114	1,0542	0,0402	44,0722	0,0114	1,0285	0,0402
MATTOCK (1965)	G1	27,37	2,9	1	0,8	27868,5518	0,004	0,0015	27,3700	0,0139	1,0000	0,0306	27,3700	0,0139	1,0000	0,0306
MATTOCK (1965)	G2	28,34	2,9	1	0,8	28120,7633	0,004	0,0015	28,3400	0,0136	1,0000	0,0304	28,3400	0,0136	1,0000	0,0304
MATTOCK (1965)	G3	28,75	2,9	1	0,8	28120,7633	0,004	0,0015	28,7500	0,0134	1,0000	0,0276	28,7500	0,0134	1,0000	0,0276
MATTOCK (1965)	G4	27,23	2,9	1	0,8	27831,7706	0,004	0,0015	27,2300	0,0144	1,0000	0,0286	27,2300	0,0144	1,0000	0,0286
MATTOCK (1965)	G5	27,23	2,9	1	0,8	27831,7706	0,004	0,0015	27,2300	0,0145	1,0000	0,0266	27,2300	0,0145	1,0000	0,0266

Corley (1966)	J1	30,44	2,9	1	0,8	28651,7921	0,004	0,0015	30,4400	0,0431	1,0000	0,1883	30,4400	0,0431	1,0000	0,1883
Corley (1966)	J11	30,65	2,9	1	0,8	28651,7921	0,004	0,0015	30,6500	0,0466	1,0000	0,1931	30,6500	0,0466	1,0000	0,1931
Corley (1966)	J2	24,65	2,9	1	0,8	27135,7623	0,004	0,0015	24,6500	0,0573	1,0000	0,2071	24,6500	0,0573	1,0000	0,2071
Corley (1966)	J21	25,79	2,9	1	0,8	27447,6643	0,004	0,0015	25,7900	0,0567	1,0000	0,2025	25,7900	0,0567	1,0000	0,2025
Corley (1966)	J3	28,3	2,9	1	0,8	28110,4522	0,004	0,0015	28,3000	0,1012	1,0000	0,3772	28,3000	0,1012	1,0000	0,3772
Corley (1966)	J4	26,34	2,9	1	0,8	27595,6369	0,004	0,0015	26,3400	0,0571	1,0000	0,1377	26,3400	0,0571	1,0000	0,1377
Corley (1966)	J41	26,06	2,9	1	0,8	27520,5046	0,004	0,0015	26,0600	0,0559	1,0000	0,1347	26,0600	0,0559	1,0000	0,1347
Corley (1966)	J42	28,82	2,9	1	0,8	28243,9104	0,004	0,0015	28,8200	0,0492	1,0000	0,1177	28,8200	0,0492	1,0000	0,1177
Corley (1966)	J5	28,06	2,9	1	0,8	28048,4258	0,004	0,0015	28,0600	0,0976	1,0000	0,2091	28,0600	0,0976	1,0000	0,2091
Corley (1966)	J6	28,68	2,9	1	0,8	28208,1037	0,004	0,0015	28,6800	0,0518	1,0000	0,1120	28,6800	0,0518	1,0000	0,1120
Corley (1966)	J61	29,03	2,9	1	0,8	28297,4507	0,004	0,0015	29,0300	0,0490	1,0000	0,1051	29,0300	0,0490	1,0000	0,1051
Corley (1966)	K1	27,23	2,9	1	0,8	27831,7706	0,004	0,0015	27,2300	0,0240	1,0000	0,0291	27,2300	0,0240	1,0000	0,0291
Corley (1966)	K2	28,44	2,9	1	0,8	28146,508	0,004	0,0015	28,4400	0,0221	1,0000	0,0271	28,4400	0,0221	1,0000	0,0271
Corley (1966)	K3	27,54	2,9	1	0,8	27913,0843	0,004	0,0015	27,5400	0,0467	1,0000	0,0573	27,5400	0,0467	1,0000	0,0573
Corley (1966)	K4	30	2,9	1	0,8	28542,1618	0,004	0,0015	30,0000	0,0211	1,0000	0,0275	30,0000	0,0211	1,0000	0,0275
Corley (1966)	K5	25,68	2,9	1	0,8	27417,8773	0,004	0,0015	27,3843	0,0086	1,0664	0,0279	26,4058	0,0086	1,0283	0,0279
Corley (1966)	K51	29,68	2,9	1	0,8	28461,8977	0,004	0,0015	34,3021	0,0210	1,1557	0,0927	32,5169	0,0210	1,0956	0,0927
Corley (1966)	K6	27,13	2,9	1	0,8	27805,4386	0,004	0,0015	28,8423	0,0083	1,0631	0,0278	27,8437	0,0083	1,0263	0,0278
Corley (1966)	K7	24,65	2,9	1	0,8	27135,7623	0,004	0,0015	27,9813	0,0154	1,1351	0,0329	26,5741	0,0154	1,0781	0,0329
Corley (1966)	K8	26,41	2,9	1	0,8	27614,3561	0,004	0,0015	28,1419	0,0085	1,0656	0,0167	27,1437	0,0085	1,0278	0,0167
Corley (1966)	K9	29,34	2,9	1	0,8	28376,1174	0,004	0,0015	33,1773	0,0104	1,1308	0,0451	31,3291	0,0104	1,0678	0,0451
Corley (1966)	K10	26,2	2,9	1	0,8	27558,122	0,004	0,0015	28,0267	0,0078	1,0697	0,0273	26,9231	0,0078	1,0276	0,0273
Corley (1966)	K11	26,79	2,9	1	0,8	27715,534	0,004	0,0015	34,0777	0,0198	1,2720	0,0930	31,9604	0,0198	1,1930	0,0930
Corley (1966)	K12	25,4	2,9	1	0,8	27341,762	0,004	0,0015	27,1802	0,0078	1,0701	0,0263	26,1063	0,0078	1,0278	0,0263
Corley (1966)	M1	31,27	2,9	1	0,8	28856,3373	0,004	0,0015	31,2700	0,0096	1,0000	0,0215	31,2700	0,0096	1,0000	0,0215
Corley (1966)	M2	28,85	2,9	1	0,8	28251,5715	0,004	0,0015	28,8500	0,0100	1,0000	0,0206	28,8500	0,0100	1,0000	0,0206
Corley (1966)	M3	30,68	2,9	1	0,8	28711,238	0,004	0,0015	30,6800	0,0151	1,0000	0,0241	30,6800	0,0151	1,0000	0,0241
Corley (1966)	M4	29,68	2,9	1	0,8	28461,8977	0,004	0,0015	29,6800	0,0100	1,0000	0,0145	29,6800	0,0100	1,0000	0,0145
Corley (1966)	M5	29,06	2,9	1	0,8	28305,0828	0,004	0,0015	29,5860	0,0105	1,0181	0,0244	29,2411	0,0105	1,0062	0,0244
Corley (1966)	M6	30,03	2,9	1	0,8	28549,6634	0,004	0,0015	30,2930	0,0082	1,0088	0,0194	30,0963	0,0082	1,0022	0,0194
Corley (1966)	M7	28,96	2,9	1	0,8	28279,6265	0,004	0,0015	29,4880	0,0105	1,0182	0,0147	29,1423	0,0105	1,0063	0,0147
Corley (1966)	M8	30,47	2,9	1	0,8	28659,2363	0,004	0,0015	30,7365	0,0082	1,0087	0,0114	30,5372	0,0082	1,0022	0,0114
Corley (1966)	N1	31,85	2,9	1	0,8	28997,5668	0,004	0,0015	31,8500	0,0100	1,0000	0,0161	31,8500	0,0100	1,0000	0,0161
Corley (1966)	N2	31,13	2,9	1	0,8	28822,0392	0,004	0,0015	31,1300	0,0079	1,0000	0,0121	31,1300	0,0079	1,0000	0,0121
Corley (1966)	N3	32,23	2,9	1	0,8	29089,3547	0,004	0,0015	32,2300	0,0134	1,0000	0,0202	32,2300	0,0134	1,0000	0,0202
Corley (1966)	N4	29,65	2,9	1	0,8	28454,3497	0,004	0,0015	29,6500	0,0083	1,0000	0,0106	29,6500	0,0083	1,0000	0,0106
Corley (1966)	N5	27,2	2,9	1	0,8	27823,8762	0,004	0,0015	27,2000	0,0094	1,0000	0,0221	27,2000	0,0094	1,0000	0,0221
Corley (1966)	N6	25,65	2,9	1	0,8	27409,7424	0,004	0,0015	25,6500	0,0097	1,0000	0,0212	25,6500	0,0097	1,0000	0,0212
Corley (1966)	N7	32,72	2,9	1	0,8	29206,863	0,004	0,0015	32,7200	0,0114	1,0000	0,0186	32,7200	0,0114	1,0000	0,0186
Corley (1966)	N8	29,37	2,9	1	0,8	28383,7071	0,004	0,0015	29,3700	0,0090	1,0000	0,0124	29,3700	0,0090	1,0000	0,0124
KWAK (2007)	BEAMR6	31	3,2	1	0,8	24804	0,004	0,0015	32,5119	0,0113	1,0488	0,0611	31,7401	0,0113	1,0239	0,0611
KWAK (2007)	BEAMR4	30	3,2	1	0,8	22785	0,004	0,0015	31,4838	0,0115	1,0495	0,0505	30,7307	0,0115	1,0244	0,0505
KWAK (2007)	BEAMS1	34	3,2	1	0,8	27770	0,004	0,0015	34,0000	0,0255	1,0000	0,0952	34,0000	0,0255	1,0000	0,0952
KWAK (2007)	COLUMN1	29,35	2,9	1	0,8	28378,6478	0,004	0,0015	29,3500	0,0090	1,0000	0,0124	29,3500	0,0090	1,0000	0,0124

BOSCO DEBERNARDI	193_T1A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1401	29,9930	0,0225	0,9968	0,1401
BOSCO DEBERNARDI	193_T1B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1418	29,9930	0,0225	0,9968	0,1418
BOSCO DEBERNARDI	193_T1A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1402	29,9930	0,0225	0,9968	0,1402
BOSCO DEBERNARDI	193_T1B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1418	29,9930	0,0225	0,9968	0,1418
BOSCO DEBERNARDI	193_T2A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1020	29,9911	0,0225	0,9967	0,1020
BOSCO DEBERNARDI	193_T2B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1013	29,9911	0,0225	0,9967	0,1013
BOSCO DEBERNARDI	193_T2A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1020	29,9911	0,0225	0,9967	0,1020
BOSCO DEBERNARDI	193_T2B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,1013	29,9911	0,0225	0,9967	0,1013
BOSCO DEBERNARDI	193_T3A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,0513	29,9897	0,0225	0,9967	0,0513
BOSCO DEBERNARDI	193_T3B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,0510	29,9897	0,0225	0,9967	0,0510
BOSCO DEBERNARDI	193_T3A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,0513	29,9897	0,0225	0,9967	0,0513
BOSCO DEBERNARDI	193_T3B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0225	1,0000	0,0510	29,9897	0,0225	0,9967	0,0510
BOSCO DEBERNARDI	193_T4A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0789	30,0900	0,0110	1,0000	0,0789
BOSCO DEBERNARDI	193_T4B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0794	30,0900	0,0110	1,0000	0,0794
BOSCO DEBERNARDI	193_T4A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0789	30,0900	0,0110	1,0000	0,0789
BOSCO DEBERNARDI	193_T4B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0794	30,0900	0,0110	1,0000	0,0794
BOSCO DEBERNARDI	193_T5A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0566	30,0900	0,0110	1,0000	0,0566
BOSCO DEBERNARDI	193_T5B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0561	30,0900	0,0110	1,0000	0,0561
BOSCO DEBERNARDI	193_T5A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0566	30,0900	0,0110	1,0000	0,0566
BOSCO DEBERNARDI	193_T5B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0561	30,0900	0,0110	1,0000	0,0561
BOSCO DEBERNARDI	193_T6A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0193	30,0900	0,0110	1,0000	0,0193
BOSCO DEBERNARDI	193_T6B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0191	30,0900	0,0110	1,0000	0,0191
BOSCO DEBERNARDI	193_T6A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0193	30,0900	0,0110	1,0000	0,0193
BOSCO DEBERNARDI	193_T6B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0191	30,0900	0,0110	1,0000	0,0191
BOSCO DEBERNARDI	193_T7A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0122	30,0900	0,0110	1,0000	0,0122
BOSCO DEBERNARDI	193_T7B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0123	30,0900	0,0110	1,0000	0,0123
BOSCO DEBERNARDI	193_T7A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0122	30,0900	0,0110	1,0000	0,0122
BOSCO DEBERNARDI	193_T7B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0110	1,0000	0,0123	30,0900	0,0110	1,0000	0,0123
BOSCO DEBERNARDI	193_T8A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0638	30,0900	0,0104	1,0000	0,0638
BOSCO DEBERNARDI	193_T8B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0642	30,0900	0,0104	1,0000	0,0642
BOSCO DEBERNARDI	193_T8A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0638	30,0900	0,0104	1,0000	0,0638
BOSCO DEBERNARDI	193_T8B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0642	30,0900	0,0104	1,0000	0,0642
BOSCO DEBERNARDI	193_T9A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0668	30,0900	0,0104	1,0000	0,0668
BOSCO DEBERNARDI	193_T9B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0672	30,0900	0,0104	1,0000	0,0672
BOSCO DEBERNARDI	193_T9A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0668	30,0900	0,0104	1,0000	0,0668
BOSCO DEBERNARDI	193_T9B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0672	30,0900	0,0104	1,0000	0,0672
BOSCO DEBERNARDI	193_T10A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0364	30,0900	0,0104	1,0000	0,0364
BOSCO DEBERNARDI	193_T10B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0360	30,0900	0,0104	1,0000	0,0360
BOSCO DEBERNARDI	193_T10A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0364	30,0900	0,0104	1,0000	0,0364
BOSCO DEBERNARDI	193_T10B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0360	30,0900	0,0104	1,0000	0,0360
BOSCO DEBERNARDI	193_T11A1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0134	30,0900	0,0104	1,0000	0,0134
BOSCO DEBERNARDI	193_T11B1	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0132	30,0900	0,0104	1,0000	0,0132
BOSCO DEBERNARDI	193_T11A3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0134	30,0900	0,0104	1,0000	0,0134
BOSCO DEBERNARDI	193_T11B3	30,09	2,97	1	0,8	28564,6548	0,004	0,0015	30,0900	0,0104	1,0000	0,0132	30,0900	0,0104	1,0000	0,0132

PAPER NAME	Section	fy	esmax	Es	n	Scrm	w*	Lp	Fi	rec	Acef	rho_ef	fy_As'	fy_Stirrups	es_max'	es_maxStirrups
DEBERNARDI [May 200	T1A1	587	0,070	200000	9,09	157,97	2	193,7	12,00	16,0	5742,1	0,020	587	587	0,070	0,070
DEBERNARDI [May 200	T1A3	587	0,070	200000	9,09	157,97	2	193,7	12	16,0	5742,1	0,020	587	587	0,070	0,070
DEBERNARDI [May 200	T2A1	587	0,070	200000	9,09	102,92	2	193,7	12	16,0	5379,8	0,042	587	587	0,070	0,070
DEBERNARDI [May 200	T2A3	587	0,070	200000	9,09	102,92	2	193,7	12	16,0	5379,8	0,042	587	587	0,070	0,070
DEBERNARDI [May 200	T3A1	587	0,070	200000	9,09	81,81	2	193,7	12	16,0	4558,5	0,074	587	587	0,070	0,070
DEBERNARDI [May 200	T3A3	587	0,070	200000	9,09	81,81	2	193,7	12	16,0	4558,5	0,074	587	587	0,070	0,070
DEBERNARDI [May 200	T4A1	587	0,070	200000	9,09	290,43	2	288,2	12	39,0	17500,0	0,013	587	587	0,070	0,070
DEBERNARDI [May 200	T4A3	587	0,070	200000	9,09	290,43	2	288,2	12	39,0	17500,0	0,013	587	587	0,070	0,070
DEBERNARDI [May 200	T5A1	587	0,070	200000	9,09	211,51	2	288,2	12	39,0	17500,0	0,026	587	587	0,070	0,070
DEBERNARDI [May 200	T5A3	587	0,070	200000	9,09	211,51	2	288,2	12	39,0	17500,0	0,026	587	587	0,070	0,070
DEBERNARDI [May 200	T6A1	587	0,070	200000	9,09	177,37	2	285,7	12	39,0	19858,2	0,046	587	587	0,070	0,070
DEBERNARDI [May 200	T6A3	587	0,070	200000	9,09	177,37	2	285,7	12	39,0	19858,2	0,046	587	587	0,070	0,070
DEBERNARDI [May 200	T7A1	587	0,070	200000	9,09	156,76	2	280,7	12	39,0	16070,2	0,084	587	587	0,070	0,070
DEBERNARDI [May 200	T7A3	587	0,070	200000	9,09	156,76	2	280,7	12	39,0	16070,2	0,084	587	587	0,070	0,070
DEBERNARDI [May 200	T8A1	587	0,070	200000	9,09	454,34	2	388,2	12	64,0	26250,0	0,009	587	587	0,070	0,070
DEBERNARDI [May 200	T8A3	587	0,070	200000	9,09	454,34	2	388,2	12	64,0	26250,0	0,009	587	587	0,070	0,070
DEBERNARDI [May 200	T9A1	587	0,070	200000	9,09	335,97	2	388,2	12	64,0	26250,0	0,017	587	587	0,070	0,070
DEBERNARDI [May 200	T9A3	587	0,070	200000	9,09	335,97	2	388,2	12	64,0	26250,0	0,017	587	587	0,070	0,070
DEBERNARDI [May 200	T10A1	587	0,070	200000	9,09	270,21	2	388,2	12	64,0	26250,0	0,039	587	587	0,070	0,070
DEBERNARDI [May 200	T10A3	587	0,070	200000	9,09	270,21	2	388,2	12	64,0	26250,0	0,039	587	587	0,070	0,070
DEBERNARDI [May 200	T11A1	587	0,070	200000	9,09	243,90	2	388,2	12	64,0	26250,0	0,078	587	587	0,070	0,070
DEBERNARDI [May 200	T11A3	587	0,070	200000	9,09	243,90	2	388,2	12	64,0	26250,0	0,078	587	587	0,070	0,070
MATTOCK (1965)	A1	315	0,030	195.811	6,57	112,60	2	231,3	22	14,5	9711,7	0,059	340	340	0,029	0,029
MATTOCK (1965)	A2	318	0,030	195.811	6,38	112,60	2	232,2	22	14,5	9711,7	0,059	340	380	0,029	0,029
MATTOCK (1965)	A3	336	0,030	195.811	6,44	112,60	2	238,3	22	14,5	9711,7	0,059	340	383	0,029	0,029
MATTOCK (1965)	A4	315	0,030	195.811	6,36	80,88	2	231,3	22	14,5	9711,7	0,118	343	343	0,029	0,029
MATTOCK (1965)	A5	314	0,030	195.811	6,50	80,88	2	231,0	22	14,5	9711,7	0,118	332	332	0,029	0,029
MATTOCK (1965)	A6	328	0,030	195.811	6,43	80,88	2	235,6	22	14,5	9711,7	0,118	332	386	0,029	0,029
MATTOCK (1965)	B1	328	0,030	194.432	6,36	80,91	2	362,9	22	14,5	9719,4	0,118	340	340	0,029	0,029
MATTOCK (1965)	B2	322	0,030	194.432	6,40	80,91	2	360,8	22	14,5	9719,4	0,118	336	336	0,029	0,029
MATTOCK (1965)	B3	322	0,030	194.432	6,36	129,94	2	360,8	22	33,6	9719,4	0,236	355	355	0,029	0,029
MATTOCK (1965)	B4	322	0,030	194.432	6,36	129,94	2	360,8	22	33,6	9719,4	0,236	337	337	0,029	0,029
MATTOCK (1965)	C1	329	0,030	195.121	7,17	112,65	2	235,8	22	14,5	9719,4	0,059	341	341	0,029	0,029
MATTOCK (1965)	C2	329	0,030	195.121	7,27	112,65	2	235,8	22	14,5	9719,4	0,059	341	439	0,029	0,029
MATTOCK (1965)	C2A	326	0,030	195.121	7,10	112,65	2	234,9	22	14,5	9719,4	0,059	341	405	0,029	0,029
MATTOCK (1965)	C2B	323	0,030	195.121	7,13	112,65	2	233,8	22	14,5	9719,4	0,059	341	410	0,029	0,029
MATTOCK (1965)	C3	330	0,030	195.121	7,30	112,65	2	236,2	22	14,5	9719,4	0,059	341	396	0,029	0,029
MATTOCK (1965)	C4	325	0,030	195.121	7,28	78,71	2	234,7	22	14,5	9047,8	0,127	341	341	0,029	0,029
MATTOCK (1965)	C5	328	0,030	195.121	7,47	76,62	2	235,6	22	14,5	8407,5	0,136	335	334	0,029	0,029
MATTOCK (1965)	C5A	321	0,030	195.121	7,08	80,76	2	233,3	22	14,5	9673,9	0,118	352	352	0,029	0,029
MATTOCK (1965)	C5B	324	0,030	195.121	7,11	77,90	2	234,2	22	14,5	8797,3	0,130	352	354	0,029	0,029
MATTOCK (1965)	C6	319	0,030	195.121	7,18	79,92	2	232,6	22	14,5	9416,7	0,122	334	427	0,029	0,029
MATTOCK (1965)	D1	319	0,030	194.432	7,18	80,91	2	359,9	22	14,5	9719,4	0,118	335	345	0,029	0,029
MATTOCK (1965)	D2	316	0,030	194.432	7,30	80,91	2	359,0	22	14,5	9719,4	0,118	334	334	0,029	0,029
MATTOCK (1965)	D2A	308	0,030	194.432	7,31	80,91	2	356,0	22	14,5	9719,4	0,118	352	352	0,029	0,029
MATTOCK (1965)	D3	320	0,030	194.432	7,27	141,84	2	360,2	22	33,6	17007,0	0,135	341	341	0,029	0,029
MATTOCK (1965)	D4	322	0,030	194.432	7,21	141,84	2	360,8	22	33,6	17007,0	0,135	320	320	0,029	0,029
MATTOCK (1965)	D4A	308	0,030	194.432	7,16	141,84	2	356,0	22	33,6	17007,0	0,135	353	353	0,029	0,029
MATTOCK (1965)	E1	404	0,030	192.363	7,13	112,60	2	260,6	22	14,5	9711,7	0,059	505	480	0,028	0,027
MATTOCK (1965)	E2	414	0,030	192.363	7,13	112,60	2	263,9	22	14,5	9711,7	0,059	501	478	0,028	0,027
MATTOCK (1965)	E3	412	0,030	192.363	7,02	112,60	2	263,3	22	14,5	9711,7	0,059	501	497	0,028	0,027
MATTOCK (1965)	F1	404	0,030	192.363	6,43	112,60	2	260,6	22	14,5	9711,7	0,059	505	470	0,028	0,027
MATTOCK (1965)	F2	415	0,030	192.363	6,42	112,60	2	264,2	22	14,5	9711,7	0,059	470	481	0,028	0,027
MATTOCK (1965)	F3	415	0,030	192.363	6,36	112,60	2	264,2	22	14,5	9711,7	0,059	464	500	0,028	0,027
MATTOCK (1965)	G1	415	0,030	197.190	7,18	91,49	2	391,5	22	14,5	9719,4	0,088	507	480	0,028	0,027
MATTOCK (1965)	G2	415	0,030	197.190	7,11	91,49	2	391,5	22	14,5	9719,4	0,088	483	483	0,028	0,027
MATTOCK (1965)	G3	415	0,030	197.190	7,11	80,91	2	391,5	22	14,5	9719,4	0,118	470	480	0,028	0,027
MATTOCK (1965)	G4	415	0,030	197.190	7,19	80,91	2	391,5	22	14,5	9719,4	0,118	505	505	0,028	0,027
MATTOCK (1965)	G5	417	0,030	197.190	7,19	112,65	2	392,2	22	14,5	9719,4	0,059	508	508	0,028	0,027

Corley (1966)	J1	483	0,066	200000	6,98	108,58	2	222,9	22	14,5	3158,5	0,063	548	334	0,066	0,066
Corley (1966)	J11	483	0,066	200000	6,98	107,05	2	222,9	22	14,5	3077,1	0,065	548	342	0,066	0,066
Corley (1966)	J2	478	0,066	200000	7,37	106,39	2	221,3	22	14,5	3042,0	0,065	545	343	0,066	0,066
Corley (1966)	J21	478	0,066	200000	7,29	106,53	2	221,3	22	14,5	3049,4	0,065	545	352	0,066	0,066
Corley (1966)	J3	553	0,071	200000	7,11	105,95	2	246,1	22	14,5	3018,7	0,066	542	354	0,071	0,071
Corley (1966)	J4	555	0,072	200000	7,25	91,44	2	246,8	22	14,5	2876,5	0,088	539	359	0,072	0,072
Corley (1966)	J41	555	0,072	200000	7,27	91,28	2	246,8	22	14,5	2865,6	0,089	539	350	0,072	0,072
Corley (1966)	J42	555	0,072	200000	7,08	91,28	2	246,8	22	14,5	2865,6	0,089	527	341	0,072	0,072
Corley (1966)	J5	471	0,065	200000	7,13	88,07	2	219,0	22	14,5	2978,2	0,096	542	343	0,065	0,065
Corley (1966)	J6	479	0,066	200000	7,09	88,04	2	221,8	22	14,5	2975,6	0,096	533	354	0,066	0,066
Corley (1966)	J61	475	0,066	200000	7,07	88,10	2	220,4	22	14,5	2980,6	0,096	533	342	0,066	0,066
Corley (1966)	K1	493	0,067	200000	7,19	94,87	2	290,0	22	14,5	4859,0	0,082	533	328	0,067	0,067
Corley (1966)	K2	461	0,065	200000	7,11	94,87	2	279,3	22	14,5	4859,0	0,082	481	314	0,065	0,065
Corley (1966)	K3	479	0,066	200000	7,17	94,87	2	285,4	22	14,5	4859,0	0,082	482	345	0,066	0,066
Corley (1966)	K4	465	0,065	200000	7,01	94,87	2	280,6	22	14,5	4859,0	0,082	492	314	0,065	0,065
Corley (1966)	K5	459	0,064	200000	7,29	117,69	2	278,6	22	14,5	14570,8	0,055	483	331	0,064	0,064
Corley (1966)	K51	472	0,065	200000	7,03	117,69	2	282,9	22	14,5	14570,8	0,055	527	530	0,065	0,065
Corley (1966)	K6	467	0,065	200000	7,19	117,69	2	281,3	22	14,5	14570,8	0,055	486	325	0,065	0,065
Corley (1966)	K7	467	0,065	200000	7,37	93,31	2	281,3	22	14,5	13515,3	0,085	483	356	0,065	0,065
Corley (1966)	K8	460	0,064	200000	7,24	95,40	2	279,0	22	14,5	14156,4	0,081	479	332	0,064	0,064
Corley (1966)	K9	480	0,066	200000	7,05	122,26	2	285,7	22	14,5	19427,9	0,051	480	333	0,066	0,066
Corley (1966)	K10	477	0,066	200000	7,26	122,26	2	284,7	22	14,5	19427,9	0,051	486	335	0,066	0,066
Corley (1966)	K11	477	0,066	200000	7,22	122,26	2	284,7	22	14,5	19427,9	0,051	493	361	0,066	0,066
Corley (1966)	K12	479	0,066	200000	7,31	122,26	2	285,4	22	14,5	19427,9	0,051	493	327	0,066	0,066
Corley (1966)	M1	444	0,063	200000	6,93	140,04	2	452,1	22	27,2	21873,3	0,079	486	485	0,063	0,063
Corley (1966)	M2	444	0,063	200000	7,08	140,04	2	452,0	22	27,2	21873,3	0,079	486	483	0,063	0,063
Corley (1966)	M3	438	0,063	200000	6,97	127,40	2	450,0	22	27,2	21873,3	0,107	484	476	0,063	0,063
Corley (1966)	M4	438	0,063	200000	7,03	127,40	2	450,0	22	27,2	21873,3	0,107	484	488	0,063	0,063
Corley (1966)	M5	447	0,064	200000	7,07	140,04	2	453,1	22	27,2	29164,7	0,079	489	481	0,064	0,064
Corley (1966)	M6	442	0,063	200000	7,01	140,04	2	451,3	22	27,2	29164,7	0,079	489	482	0,063	0,063
Corley (1966)	M7	437	0,063	200000	7,07	123,51	2	449,7	22	27,2	29164,7	0,120	489	480	0,063	0,063
Corley (1966)	M8	441	0,063	200000	6,98	123,51	2	450,9	22	27,2	29164,7	0,120	489	483	0,063	0,063
Corley (1966)	N1	429	0,062	200000	6,90	122,40	2	523,3	22	27,2	21867,6	0,125	483	467	0,062	0,062
Corley (1966)	N2	423	0,062	200000	6,94	122,40	2	521,5	22	27,2	21867,6	0,125	481	453	0,062	0,062
Corley (1966)	N3	423	0,062	200000	6,88	119,19	2	521,5	22	27,2	21867,6	0,140	483	437	0,062	0,062
Corley (1966)	N4	421	0,062	200000	7,03	119,19	2	520,6	22	27,2	21867,6	0,140	493	470	0,062	0,062
Corley (1966)	N5	425	0,062	200000	7,19	135,27	2	522,0	22	27,2	29160,0	0,087	478	439	0,062	0,062
Corley (1966)	N6	430	0,062	200000	7,30	135,27	2	523,6	22	27,2	29160,0	0,087	472	437	0,062	0,062
Corley (1966)	N7	423	0,062	200000	6,85	119,20	2	521,5	22	27,2	29160,0	0,140	483	432	0,062	0,062
Corley (1966)	N8	427	0,062	200000	7,05	119,20	2	522,7	22	27,2	29160,0	0,140	481	436	0,062	0,062
KWAK (2007)	BEAMR6	451	0,064	200000	8,06	113,75	2	342,5	22	23,9	10915,7	0,115	451	451	0,064	0,064
KWAK (2007)	BEAMR4	451	0,064	200000	8,78	113,75	2	342,5	22	23,9	10915,7	0,115	451	451	0,064	0,064
KWAK (2007)	BEAMS1	496	0,067	200000	7,20	209,17	2	290,7	22	39,8	12407,5	0,051	496	496	0,067	0,067
KWAK (2007)	COLUMN	427	0,062	200000	7,05	119,20	2	522,7	22	27,2	29160,0	0,140	481	436	0,062	0,062
BOSCO DEBERNARDI	193_T1A1	587	0,070	200000	7,00	214,73	2	264,1	20	12,0	5785,7	0,020	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T1B1	596	0,042	200000	7,00	214,42	2	266,7	20	12,0	5775,2	0,020	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T1A3	587	0,070	200000	7,00	214,72	2	264,2	20	12,0	5785,4	0,020	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T1B3	596	0,042	200000	7,00	214,42	2	266,7	20	12,0	5775,2	0,020	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T2A1	587	0,070	200000	7,00	121,67	2	264,2	20	12,0	5380,0	0,042	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T2B1	596	0,042	200000	7,00	121,49	2	266,7	20	12,0	5368,2	0,042	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T2A3	587	0,070	200000	7,00	121,67	2	264,2	20	12,0	5380,0	0,042	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T2B3	596	0,042	200000	7,00	121,49	2	266,7	20	12,0	5368,2	0,042	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T3A1	587	0,070	200000	7,00	88,15	2	264,2	20	12,0	4724,9	0,072	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T3B1	596	0,042	200000	7,00	87,87	2	266,7	20	12,0	4697,5	0,072	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T3A3	587	0,070	200000	7,00	88,15	2	264,2	20	12,0	4724,9	0,072	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T3B3	596	0,042	200000	7,00	87,87	2	266,7	20	12,0	4697,5	0,072	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T4A1	587	0,070	200000	7,00	382,05	2	358,7	20	35,0	17500,0	0,013	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T4B1	596	0,042	200000	7,00	382,05	2	361,2	20	35,0	17500,0	0,013	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T4A3	587	0,070	200000	7,00	382,05	2	358,7	20	35,0	17500,0	0,013	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T4B3	596	0,042	200000	7,00	382,05	2	361,2	20	35,0	17500,0	0,013	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T5A1	587	0,070	200000	7,00	250,52	2	358,7	20	35,0	17500,0	0,026	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T5B1	596	0,042	200000	7,00	250,52	2	361,2	20	35,0	17500,0	0,026	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T5A3	587	0,070	200000	7,00	250,52	2	358,7	20	35,0	17500,0	0,026	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T5B3	596	0,042	200000	7,00	250,52	2	361,2	20	35,0	17500,0	0,026	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T6A1	587	0,070	200000	7,00	194,16	2	356,2	20	35,0	20000,0	0,045	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T6B1	596	0,042	200000	7,00	194,16	2	358,7	20	35,0	20000,0	0,045	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T6A3	587	0,070	200000	7,00	194,16	2	356,2	20	35,0	20000,0	0,045	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T6B3	596	0,042	200000	7,00	194,16	2	358,7	20	35,0	20000,0	0,045	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T7A1	587	0,070	200000	7,00	162,76	2	351,2	20	35,0	17468,9	0,078	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T7B1	596	0,042	200000	7,00	162,44	2	353,7	20	35,0	17338,9	0,078	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T7A3	587	0,070	200000	7,00	162,76	2	351,2	20	35,0	17468,9	0,078	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T7B3	596	0,042	200000	7,00	162,44	2	353,7	20	35,0	17338,9	0,078	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T8A1	587	0,070	200000	7,00	598,58	2	458,7	20	60,0	26250,0	0,009	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T8B1	596	0,042	200000	7,00	598,58	2	461,2	20	60,0	26250,0	0,009	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T8A3	587	0,070	200000	7,00	598,58	2	458,7	20	60,0	26250,0	0,009	587	587	0,070	0,070

BOSCO DEBERNARDI	193_T8B3	596	0,042	200000	7,00	598,58	2	461,2	20	60,0	26250,0	0,009	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T9A1	587	0,070	200000	7,00	401,29	2	458,7	20	60,0	26250,0	0,017	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T9B1	596	0,042	200000	7,00	401,29	2	461,2	20	60,0	26250,0	0,017	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T9A3	587	0,070	200000	7,00	401,29	2	458,7	20	60,0	26250,0	0,017	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T9B3	596	0,042	200000	7,00	401,29	2	461,2	20	60,0	26250,0	0,017	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T10A	587	0,070	200000	7,00	291,68	2	458,7	20	60,0	26250,0	0,039	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T10B	596	0,042	200000	7,00	291,68	2	461,2	20	60,0	26250,0	0,039	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T10A	587	0,070	200000	7,00	291,68	2	458,7	20	60,0	26250,0	0,039	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T10B	596	0,042	200000	7,00	291,68	2	461,2	20	60,0	26250,0	0,039	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T11A	587	0,070	200000	7,00	266,63	2	451,2	20	60,0	37500,0	0,054	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T11B	596	0,042	200000	7,00	266,63	2	453,7	20	60,0	37500,0	0,054	596	587	0,042	0,070
BOSCO DEBERNARDI	193_T11A	587	0,070	200000	7,00	266,63	2	451,2	20	60,0	37500,0	0,054	587	587	0,070	0,070
BOSCO DEBERNARDI	193_T11B	596	0,042	200000	7,00	266,63	2	453,7	20	60,0	37500,0	0,054	596	587	0,042	0,070

Annexes B

GENERAL INPUT		EXPERIMENTAL	METODO MANDER														
			Fisuración		Yielding		ancho de fisura		Momento úlitmo		Rotura				ature ductility capacities (at 90% maximum l		
NOMBRE ENSAYO	Beam	θp (rad)	$\phi_{f,D}$ m^{-1}	Mf,D kNm	$\phi_{y,D}$ m^{-1}	My,D kNm	$\phi_{a,D}$ m^{-1}	Ma,D kNm	$\phi_{u,D}$ m^{-1}	Mu,D kNm	$\phi_{r,D}$ m^{-1}	Mr,D kNm	θp (rad)	**ERROR**	Without shear effect	With shear effect	%
DEBERNARDI [May 2002]	T1A1	0,102	0,001	2,00	0,02	10,57	0,09	10,89	0,15	10,89	0,56	9,83	0,104	0,98	26,0308501	23,42036011	90,0%
DEBERNARDI [May 2002]	T1A3	0,140	0,001	2,00	0,02	10,57	0,09	10,89	0,15	10,89	0,56	9,83	0,104	1,35	26,0308501	23,42036011	90,0%
DEBERNARDI [May 2002]	T2A1	0,130	0,001	2,00	0,02	18,82	0,09	21,01	0,14	20,92	0,39	19,20	0,071	1,84	16,03668193	15,37561372	95,9%
DEBERNARDI [May 2002]	T2A3	0,076	0,001	2,00	0,02	18,82	0,09	21,01	0,14	20,92	0,39	19,20	0,071	1,07	16,03668193	15,37561372	95,9%
DEBERNARDI [May 2002]	T3A1	0,030	0,001	2,00	0,02	21,35	0,06	30,21	0,22	30,05	0,20	26,99	0,036	0,84	7,588214234	#N/A	#N/A
DEBERNARDI [May 2002]	T3A3	0,014	0,001	2,00	0,02	21,35	0,06	30,21	0,22	30,05	0,20	26,99	0,036	0,39	7,588214234	#N/A	#N/A
DEBERNARDI [May 2002]	T4A1		0,001	16,00	0,01	44,99	0,02	47,41	0,11	47,04	0,23	41,90	0,064		23,14336173	20,09582744	86,8%
DEBERNARDI [May 2002]	T4A3	0,165	0,001	16,00	0,01	44,99	0,02	47,41	0,11	47,04	0,23	41,90	0,064	2,60	23,14336173	20,09582744	86,8%
DEBERNARDI [May 2002]	T5A1	0,112	0,001	16,00	0,01	87,81	0,03	90,58	0,07	90,58	0,16	81,17	0,042	2,65	15,00865681	13,0458417	86,9%
DEBERNARDI [May 2002]	T5A3	0,094	0,001	16,00	0,01	87,81	0,03	90,58	0,07	90,58	0,16	81,17	0,042	2,22	15,00865681	13,0458417	86,9%
DEBERNARDI [May 2002]	T6A1	0,027	0,001	16,00	0,01	146,94	0,04	169,18	0,04	168,90	0,06	149,08	0,015	1,85	5,095422456	5,047593376	99,1%
DEBERNARDI [May 2002]	T6A3	0,016	0,001	16,00	0,01	146,94	0,04	169,18	0,04	168,90	0,06	149,08	0,015	1,10	5,095422456	5,047593376	99,1%
DEBERNARDI [May 2002]	T7A1	0,008	0,001	16,00	0,01	159,08	0,03	229,89	0,07	229,73	0,05	174,09	0,010	0,81	4,683727618	#N/A	#N/A
DEBERNARDI [May 2002]	T7A3	0,013	0,001	16,00	0,01	159,08	0,03	229,89	0,07	229,73	0,05	174,09	0,010	1,31	4,683727618	#N/A	#N/A
DEBERNARDI [May 2002]	T8A1	0,047	0,000	54,00	0,01	71,34	0,01	80,07	0,10	74,88	0,15	64,98	0,054	0,87	23,45384785	18,20960923	77,6%
DEBERNARDI [May 2002]	T8A3	0,083	0,000	54,00	0,01	71,34	0,01	80,07	0,10	74,88	0,15	64,98	0,054	1,54	23,45384785	18,20960923	77,6%
DEBERNARDI [May 2002]	T9A1		0,000	54,00	0,01	140,00	0,01	148,16	0,08	146,33	0,15	128,77	0,057		23,20798204	20,00938749	86,2%
DEBERNARDI [May 2002]	T9A3	0,079	0,000	54,00	0,01	140,00	0,01	148,16	0,08	146,33	0,15	128,77	0,057	1,39	23,20798204	20,00938749	86,2%
DEBERNARDI [May 2002]	T10A1	0,039	0,000	54,00	0,01	306,15	0,02	316,12	0,05	316,10	0,08	279,95	0,029	1,36	11,49623204	10,43638153	90,8%
DEBERNARDI [May 2002]	T10A3	0,043	0,000	54,00	0,01	306,15	0,02	316,12	0,05	316,10	0,08	279,95	0,029	1,50	11,49623204	10,43638153	90,8%
DEBERNARDI [May 2002]	T11A1	0,011	0,000	54,00	0,01	526,63	0,02	596,26	0,02	595,38	0,04	521,78	0,011	1,01	4,497792269	4,665934088	103,7%
DEBERNARDI [May 2002]	T11A3	0,011	0,000	54,00	0,01	526,63	0,02	596,26	0,02	595,38	0,04	521,78	0,011	1,01	4,497792269	4,665934088	103,7%
MATTOCK (1965)	A1	0,057	0,001	6,38	0,01	40,77	0,08	43,22	0,12	43,21	0,16	39,59	0,035	1,65	17,1148703	13,82661448	80,8%
MATTOCK (1965)	A2	0,056	0,001	6,38	0,01	41,18	0,08	43,79	0,13	43,79	0,16	40,03	0,034	1,63	16,79839667	15,38268684	91,6%
MATTOCK (1965)	A3	0,053	0,001	6,38	0,01	43,57	0,08	46,16	0,12	46,15	0,16	42,22	0,035	1,50	15,90698752	14,42974492	90,7%
MATTOCK (1965)	A4	0,035	0,001	6,38	0,01	78,68	0,07	83,18	0,13	83,18	0,17	75,24	0,036	0,97	15,42747338	12,91204687	83,7%
MATTOCK (1965)	A5	0,028	0,001	6,38	0,01	78,42	0,06	82,37	0,13	82,37	0,10	74,42	0,020	1,38	9,251830883	8,450863385	91,3%
MATTOCK (1965)	A6	0,024	0,001	6,38	0,01	81,90	0,06	85,87	0,13	85,87	0,07	77,51	0,014	1,76	6,215650206	5,72153383	92,1%
MATTOCK (1965)	B1	0,035	0,000	23,27	0,01	170,28	0,06	181,94	0,06	181,94	0,08	173,61	0,026	1,35	15,04073014	13,88054251	92,3%
MATTOCK (1965)	B2	0,035	0,000	23,27	0,00	167,01	0,06	178,45	0,06	178,45	0,07	170,29	0,022	1,61	13,07068268	12,36359664	94,6%
MATTOCK (1965)	B3	0,019	0,000	23,27	0,01	320,75	0,03	337,17	0,04	337,17	0,06	306,58	0,018	1,03	10,02252783	9,071469369	90,5%
MATTOCK (1965)	B4	0,015	0,000	23,27	0,01	320,75	0,03	336,95	0,04	336,95	0,03	306,25	0,010	1,54	5,934542538	5,436376275	91,6%
MATTOCK (1965)	C1	0,051	0,001	6,39	0,01	42,40	0,08	44,34	0,09	44,32	0,18	40,76	0,039	1,29	18,00618466	15,13230886	84,0%
MATTOCK (1965)	C2	0,044	0,001	6,39	0,01	42,38	0,08	44,23	0,09	44,21	0,14	40,67	0,030	1,48	13,91837651	12,70116014	91,3%
MATTOCK (1965)	C2A	0,044	0,001	6,39	0,01	42,06	0,08	44,07	0,10	44,04	0,14	40,50	0,030	1,46	14,22797758	13,03863796	91,6%
MATTOCK (1965)	C2B	0,044	0,001	6,39	0,01	41,36	0,07	43,04	0,09	43,04	0,10	38,33	0,022	2,03	8,358064469	9,428366356	112,8%
MATTOCK (1965)	C3	0,042	0,001	5,79	0,01	42,51	0,08	44,34	0,09	44,32	0,13	40,77	0,028	1,50	12,95692595	11,25130391	86,8%
MATTOCK (1965)	C4	0,026	0,001	5,79	0,01	80,72	0,04	80,37	0,17	80,37	0,14	72,13	0,030	0,86	13,84398159	11,22797502	81,1%
MATTOCK (1965)	C5	0,017	0,001	5,79	0,01	81,29	0,03	79,39	0,19	79,39	0,08	71,04	0,015	1,10	15,56120906	6,307875621	40,5%
MATTOCK (1965)	C5A		0,001	5,79	0,01	79,81	0,04	80,95	0,15	80,95	0,09	72,87	0,018		8,247369769	7,461799848	90,5%
MATTOCK (1965)	C5B		0,001	5,79	0,01	79,76	0,04	78,55	0,17	78,55	0,08	69,10	0,015		14,45607022	6,170661338	42,7%
MATTOCK (1965)	C6	0,018	0,001	5,79	0,01	79,24	0,04	79,76	0,16	79,76	0,06	71,67	0,011	1,61	13,17591161	5,092363304	38,6%
MATTOCK (1965)	D1	0,029	0,000	21,09	0,00	164,74	0,04	172,51	0,06	172,51	0,08	164,42	0,025	1,15	15,11069907	13,67770908	90,5%
MATTOCK (1965)	D2	0,025	0,000	21,09	0,00	163,20	0,04	170,64	0,06	170,64	0,05	162,63	0,016	1,56	10,09857936	9,5039147	94,1%
MATTOCK (1965)	D2A	0,025	0,000	21,09	0,00	158,57	0,04	166,30	0,06	166,30	0,05	158,62	0,017	1,46	11,03338634	10,07865201	91,3%
MATTOCK (1965)	D3	0,013	0,000	22,62	0,01	316,39	0,02	311,92	0,05	311,92	0,06	242,54	0,019	0,68	8,086922601	7,963435199	98,5%
MATTOCK (1965)	D4	0,009	0,000	22,62	0,01	318,53	0,02	315,16	0,05	315,16	0,03	240,67	0,010	0,96	7,889755785	5,362507075	68,0%
MATTOCK (1965)	D4A	0,009	0,000	22,62	0,01	304,32	0,02	305,70	0,04	305,70	0,03	253,44	0,010	0,91	7,714733059	5,871951765	76,1%
MATTOCK (1965)	E1	0,042	0,001	5,79	0,01	52,13	0,08	53,91	0,09	53,86	0,18	49,73	0,044	0,96	15,15834864	12,7178556	83,9%
MATTOCK (1965)	E2	0,037	0,001	5,79	0,01	53,42	0,08	55,18	0,09	55,10	0,19	50,82	0,046	0,81	15,06774304	12,53558754	83,2%
MATTOCK (1965)	E3	0,036	0,001	5,79	0,01	53,24	0,08	55,12	0,09	55,08	0,18	50,80	0,044	0,82	14,73395602	13,58172227	92,2%
MATTOCK (1965)	F1	0,052	0,001	5,79	0,01	52,36	0,08	54,94	0,10	54,91	0,16	50,54	0,039	1,32	13,60623499	12,04069556	88,5%
MATTOCK (1965)	F2	0,046	0,001	5,79	0,01	53,79	0,08	56,37	0,10	56,34	0,17	51,76	0,040	1,13	13,51035569	11,81849183	87,5%
MATTOCK (1965)	F3	0,045	0,001	5,79	0,01	53,81	0,08	56,47	0,10	56,44	0,16	51,81	0,040	1,11	13,4204705	11,65392195	86,8%
MATTOCK (1965)	G1	0,030	0,000	21,09	0,01	162,83	0,05	169,98	0,05	169,98	0,08	162,75	0,031	0,97	13,90980145	13,2853024	95,5%
MATTOCK (1965)	G2	0,028	0,000	21,09	0,01	162,89	0,05	170,16	0,05	170,16	0,08	162,85	0,030	0,92	13,81984457	13,17633316	95,3%
MATTOCK (1965)	G3	0,023	0,000	21,09	0,01	214,12	0,03	221,28	0,06	221,28	0,07	210,89	0,025	0,90	11,30707844	10,04154389	88,8%
MATTOCK (1965)	G4	0,019	0,000	21,09	0,01	214,02	0,03	220,58	0,06	220,58	0,07	210,32	0,026	0,71	11,6590194	10,62900874	91,2%
MATTOCK (1965)	G5	0,042	0,000	21,09	0,01	111,02	0,04	116,10	0,07	115,76	0,07	111,81	0,027	1,59	12,85125172	11,64108513	90,6%
Corley (1966)	J1	0,235	0,001	0,88	0,03	10,52	0,12	10,54	0,19	10,54	0,88	9,53	0,188	1,25	31,69701607	26,03446118	82,1%
Corley (1966)	J11	0,209	0,001	0,86	0,03	10,50	0,11	10,53	0,20	10,52	0,90	9,53	0,193	1,08	32,2903855	27,02366683	83,7%
Corley (1966)	J2	0,210	0,001	0,86	0,03	10,31	0,11	10,28	0,20	10,26	0,97	9,42	0,207	1,02	34,75806458	26,07510557	75,0%
Corley (1966)	J21	0,219	0,001	0,86	0,03	10,37	0,11	10,31	0,20	10,29	0,95	9,42	0,203	1,08	34,08903359	26,10653416	76,6%
Corley (1966)	J3	0,453	0,001	0,86	0,03	10,51	0,10	11,89	0,20	11,85	1,56	10,68	0,377	1,20	49,99059292	24,17262687	48,4%
Corley (1966)	J4	0,163	0,001	0,86	0,03	11,28	0,08	14,99	0,25	14,78	0,72	12,14	0,171	0,95	15,60928029	11,94826542	76,5%
Corley (1966)	J41	0,155	0,001	0,86	0,03	11,26	0,08	14,98	0,25	14,77	0,71	12,09	0,169	0,92	15,36479481	11,61223038	75,6%
Corley (1966)	J42	0,132	0,001	0,86	0,03	11,42	0,08	15,07	0,24	14,89	0,64	12,40	0,150	0,88	14,48422396	13,4930535	93,2%
Corley (1966)	J5	0,292	0,001	0,86	0,03	11,80	0,08	14,41	0,25	14,25	1,14	12,62	0,244	1,20	35,19706237	25,26185545	71,8%
Corley (1966)	J6	0,109	0,001	0,86	0,03	11,84	0,08	14,67	0,25	14,50	0,61	12,51	0,129	0,84	17,24140854	14,7648024	85,6%
Corley (1966)	J61	0,116	0,001	0,86	0,03	11,86	0,09	14,56	0,25	14,40	0,58	12,57	0,123	0,95	17,38177722	13,68103264	78,7%
Corley (1966)	K1	0,030	0,001	2,90	0,02	41,41	0,05	44,51	0,12	44,45	0,14	40,90	0,035	0,87	9,077163048	8,79441636	96,9%
Corley (1966)	K10	0,044	0,001	11,58	0,01	107,06	0,06	108,73	0,09	108,70	0,12	98,40	0,030	1,45	9,227144098	8,289794443	89,8%
Corley (1966)	K11	0,100	0,001	11,58	0,01	107,09	0,06	108,98	0,08	108,90	0,38	98,62	0,105	0,95	29,18863239	22,69192507	77,7%
Corley (1966)	K12	0,025	0,001	11,58	0,01	107,49	0,06	108,85	0,09	108,83	0,12	98,50	0,029	0,85	8,943293197	8,097841081	90,5%
Corley (1966)	K2	0,031	0,001	2,90	0,01	40,77	0,06	41,86	0,11	41,86	0,13	38,95	0,032	0,95	9,227394304	8,574154183	92,9%
Corley (1966)	K3	0,060	0,001	2,90	0,02	41,48	0,06	43,23	0,12	43,23	0,25	40,14	0,067	0,90	17,20167955	13,98758631	81,3%
Corley (1966)	K4	0,040	0,001	2,90	0,01	41,16	0,06	42,39	0,11	42,34	0,13	39,43	0,033	1,23	9,262440281	8,613923864	93,0%
Corley (1966)	K5	0,032	0,001	8,68	0,01	82,11	0,06	83,63	0,09	83,61	0,12	76,09	0,031	1,05	9,711893427	8,854182432	91,2%
Corley (1966)	K51	0,093	0,001	8,68	0,01	84,60	0,07	86,91	0,09	86,72	0,32	79,06	0,088	1,06	24,58566251	21,74771873	88,5%
Corley (1966)	K6	0,045	0,001	8,68	0,01	83,64	0,07	85,40	0,09	85,34	0,12	77,66	0,031	1,46	9,528166876	8,662218874	90,9%
Corley (1966)	K7	0,040	0,001	8,68	0,01	111,98	0,04	115,13	0,14	115,13	0,15	103,28	0,037	1,08	9,428359606	9,161957744	97,2%
Corley (1966)	K8	0,023	0,001	8,68	0,01	113,25	0,04	114,97	0,13	114,97	0,08	103,31	0,019	1,25	8,793473035	5,509598844	62,7%
Corley (1966)	K9	0,083	0,001	11,58	0,01	107,85	0,07	110,40	0,08	110,31	0,19	99,90	0,051	1,63	14,65299438	13,19513776	90,1%

Corley (1966)	M1	0,016	0,000	46,66	0,01	415,43	0,03	430,17	0,03	430,15	0,05	403,68	0,021	0,75	9,731038135	9,073880866	93,2%
Corley (1966)	M2	0,017	0,000	46,66	0,01	414,61	0,03	426,96	0,03	426,96	0,05	400,50	0,020	0,85	9,411155975	8,703095119	92,5%
Corley (1966)	M3	0,020	0,000	46,66	0,01	548,02	0,02	557,93	0,04	557,93	0,06	521,49	0,023	0,86	10,51426235	9,533520769	90,7%
Corley (1966)	M4	0,013	0,000	46,66	0,01	547,77	0,02	555,75	0,04	555,75	0,04	519,31	0,014	0,95	6,707905421	6,235150946	93,0%
Corley (1966)	M5	0,018	0,000	62,21	0,01	556,73	0,03	572,08	0,03	572,08	0,06	535,62	0,024	0,75	10,94612152	10,18114897	93,0%
Corley (1966)	M6	0,012	0,000	62,21	0,01	550,09	0,03	567,32	0,03	567,32	0,05	531,35	0,019	0,65	9,013919468	8,413313599	93,3%
Corley (1966)	M7	0,018	0,000	62,21	0,01	814,02	0,02	812,92	0,04	812,92	0,04	757,06	0,014	1,26	6,800811747	6,278204211	92,3%
Corley (1966)	M8	0,014	0,000	62,21	0,01	821,04	0,02	824,39	0,04	824,39	0,03	768,07	0,011	1,31	5,467743892	5,08555475	93,0%
Corley (1966)	N1	0,023	0,000	71,20	0,00	785,56	0,02	807,29	0,03	807,29	0,03	765,29	0,016	1,45	7,963203586	7,475197527	93,9%
Corley (1966)	N2	0,019	0,000	71,20	0,00	775,62	0,02	796,53	0,03	796,53	0,03	755,07	0,012	1,59	6,36949917	5,992632315	94,1%
Corley (1966)	N3	0,042	0,000	71,20	0,00	863,42	0,02	883,21	0,03	883,21	0,04	836,49	0,020	2,10	9,858275732	9,285632617	94,2%
Corley (1966)	N4	0,022	0,000	71,20	0,00	856,81	0,02	869,67	0,03	869,67	0,02	823,33	0,010	2,20	5,599589752	5,30692916	94,8%
Corley (1966)	N5	0,028	0,000	94,94	0,00	737,52	0,02	761,10	0,03	761,10	0,05	722,44	0,022	1,26	11,45371199	10,67656551	93,2%
Corley (1966)	N6	0,018	0,000	94,94	0,00	745,38	0,02	765,07	0,02	765,07	0,04	725,92	0,021	0,86	10,94781894	10,34312184	94,5%
Corley (1966)	N7	0,016	0,000	94,94	0,00	1148,82	0,02	1171,10	0,03	1171,10	0,04	1106,31	0,018	0,89	9,225373564	8,705345106	94,4%
Corley (1966)	N8	0,012	0,000	94,94	0,00	1156,39	0,02	1162,74	0,03	1162,74	0,03	1097,41	0,012	0,95	6,495686441	6,1339346	94,4%
KWAK (2007)	BEAMR6	0,075	0,001	20,14	0,01	196,87	0,05	203,97	0,08	203,77	0,19	198,82	0,061	1,22	21,41348725	19,92003606	93,0%
KWAK (2007)	BEAMR4	0,055	0,001	20,14	0,01	194,27	0,05	203,02	0,06	202,80	0,16	192,22	0,051	1,08	17,36405367	15,57893186	89,7%
KWAK (2007)	BEAMS1	0,107	0,001	7,55	0,02	68,63	0,05	70,00	0,07	69,98	0,34	63,10	0,095	1,12	24,82784131	22,09292347	89,0%
KWAK (2007)	COLUMN1	0,009	0,000	47,36	0,00	792,34	0,01	998,61	0,07	998,61	0,02	653,76	0,011	0,80	13,26775381	5,453782135	41,1%
BOSCO DEBERNARDI	193_T1A1	0,146	0,001	1,98	0,02	10,68	0,06	10,95	0,16	10,95	0,55	9,85	0,139	1,05	26,66964242	24,04951398	90,2%
BOSCO DEBERNARDI	193_T1A3	0,151	0,001	1,98	0,02	10,68	0,06	10,96	0,16	10,95	0,55	9,85	0,139	1,08	26,66255117	24,03885287	90,2%
BOSCO DEBERNARDI	193_T1B1	0,044	0,001	1,98	0,02	10,83	0,06	11,10	0,16	11,10	0,33	9,99	0,082	0,53	15,78789274	13,17876345	83,5%
BOSCO DEBERNARDI	193_T1B3	0,049	0,001	1,98	0,02	10,83	0,06	11,10	0,16	11,10	0,33	9,99	0,082	0,60	15,78789274	13,17876345	83,5%
BOSCO DEBERNARDI	193_T2A1	0,145	0,001	1,98	0,02	20,79	0,10	21,07	0,12	21,03	0,39	19,27	0,098	1,48	17,16372488	15,63191236	91,1%
BOSCO DEBERNARDI	193_T2A3	0,124	0,001	1,98	0,02	20,79	0,10	21,07	0,12	21,03	0,39	19,27	0,098	1,26	17,16372488	15,63191236	91,1%
BOSCO DEBERNARDI	193_T2B1	0,107	0,001	1,98	0,03	21,08	0,10	21,35	0,12	21,31	0,39	19,53	0,097	1,10	16,70243718	15,15488078	90,7%
BOSCO DEBERNARDI	193_T2B3	0,051	0,001	1,98	0,03	21,08	0,10	21,35	0,12	21,31	0,39	19,53	0,097	0,52	16,70243718	15,15488078	90,7%
BOSCO DEBERNARDI	193_T3A1	0,085	0,001	1,98	0,02	24,96	0,07	30,50	0,19	30,31	0,21	27,25	0,049	1,74	7,166454977	7,836686556	109,4%
BOSCO DEBERNARDI	193_T3A3	0,019	0,001	1,98	0,02	24,96	0,07	30,50	0,19	30,31	0,21	27,25	0,049	0,40	7,166454977	7,836686556	109,4%
BOSCO DEBERNARDI	193_T3B1	0,065	0,001	1,98	0,02	24,96	0,06	30,89	0,19	30,68	0,20	27,57	0,049	1,34	7,152475915	7,487534739	104,7%
BOSCO DEBERNARDI	193_T3B3	0,023	0,001	1,98	0,02	24,96	0,06	30,89	0,19	30,68	0,20	27,57	0,049	0,46	7,152475915	7,487534739	104,7%
BOSCO DEBERNARDI	193_T4A1	0,179	0,001	15,84	0,01	45,38	0,02	47,73	0,11	47,19	0,23	41,94	0,079	2,27	23,62780375	20,29748176	85,9%
BOSCO DEBERNARDI	193_T4A3	0,218	0,001	15,84	0,01	45,38	0,02	47,73	0,11	47,19	0,23	41,94	0,079	2,77	23,62780375	20,29748176	85,9%
BOSCO DEBERNARDI	193_T4B1	0,031	0,001	15,84	0,01	46,02	0,02	48,35	0,11	47,83	0,14	42,39	0,047	0,67	10,92810173	12,82337191	117,3%
BOSCO DEBERNARDI	193_T4B3	0,029	0,001	15,84	0,01	46,02	0,02	48,35	0,11	47,83	0,14	42,39	0,047	0,63	10,92810173	12,82337191	117,3%
BOSCO DEBERNARDI	193_T5A1	0,147	0,001	15,84	0,01	88,74	0,03	91,10	0,08	91,07	0,16	81,43	0,055	2,69	15,96396168	14,5900352	91,4%
BOSCO DEBERNARDI	193_T5A3	0,237	0,001	15,84	0,01	88,74	0,03	91,10	0,08	91,07	0,16	81,43	0,055	4,35	15,96396168	14,5900352	91,4%
BOSCO DEBERNARDI	193_T5B1	0,048	0,001	15,84	0,01	89,99	0,03	92,31	0,08	92,29	0,16	82,54	0,054	0,88	15,56120013	14,10948642	90,7%
BOSCO DEBERNARDI	193_T5B3	0,037	0,001	15,84	0,01	89,99	0,03	92,31	0,08	92,29	0,16	82,54	0,054	0,68	15,56120013	14,10948642	90,7%
BOSCO DEBERNARDI	193_T6A1	0,041	0,001	15,84	0,01	169,86	0,04	170,37	0,04	170,27	0,06	150,44	0,019	2,21	5,523483773	5,103428425	92,4%
BOSCO DEBERNARDI	193_T6A3	0,028	0,001	15,84	0,01	169,86	0,04	170,37	0,04	170,27	0,06	150,44	0,019	1,53	5,523483773	5,103428425	92,4%
BOSCO DEBERNARDI	193_T6B1	0,055	0,001	15,84	0,01	172,26	0,04	172,51	0,04	172,44	0,06	152,32	0,018	2,98	5,373994719	4,988543514	92,8%
BOSCO DEBERNARDI	193_T6B3		0,001	15,84	0,01	172,26	0,04	172,51	0,04	172,44	0,06	152,32	0,018		5,373994719	4,988543514	92,8%
BOSCO DEBERNARDI	193_T7A1	0,007	0,001	15,84	0,01	191,23	0,03	236,34	0,06	235,67	0,04	199,30	0,012	0,63	4,312850804	3,796953256	88,0%
BOSCO DEBERNARDI	193_T7A3	0,006	0,001	15,84	0,01	191,23	0,03	236,34	0,06	235,67	0,04	199,30	0,012	0,50	4,312850804	3,796953256	88,0%
BOSCO DEBERNARDI	193_T7B1	0,006	0,001	15,84	0,01	191,23	0,03	239,15	0,06	238,41	0,04	199,25	0,012	0,47	4,311647891	3,759371347	87,2%
BOSCO DEBERNARDI	193_T7B3	0,013	0,001	15,84	0,01	191,23	0,03	239,15	0,06	238,41	0,04	199,25	0,012	1,14	4,311647891	3,759371347	87,2%
BOSCO DEBERNARDI	193_T8A1	0,054	0,000	53,46	0,01	71,84	0,01	80,44	0,11	74,83	0,15	65,03	0,064	0,85	24,45554815	19,17893777	78,4%
BOSCO DEBERNARDI	193_T8A3	0,097	0,000	53,46	0,01	71,84	0,01	80,44	0,11	74,83	0,15	65,03	0,064	1,52	24,45554815	19,17893777	78,4%
BOSCO DEBERNARDI	193_T8B1	0,020	0,000	53,46	0,01	72,86	0,01	81,04	0,11	75,86	0,09	65,74	0,038	0,53	17,84164368	12,80534725	71,8%
BOSCO DEBERNARDI	193_T8B3	0,020	0,000	53,46	0,01	72,86	0,01	81,04	0,11	75,86	0,09	65,74	0,038	0,54	17,84164368	12,80534725	71,8%
BOSCO DEBERNARDI	193_T9A1	0,074	0,000	53,46	0,01	141,18	0,01	149,16	0,08	146,74	0,15	128,96	0,067	1,11	23,79251519	20,3561001	85,6%
BOSCO DEBERNARDI	193_T9A3	0,103	0,000	53,46	0,01	141,18	0,01	149,16	0,08	146,74	0,15	128,96	0,067	1,55	23,79251519	20,3561001	85,6%
BOSCO DEBERNARDI	193_T9B1	0,017	0,000	53,46	0,01	143,17	0,01	151,05	0,08	148,74	0,09	130,77	0,039	0,42	12,49941347	12,53036459	100,2%
BOSCO DEBERNARDI	193_T9B3	0,020	0,000	53,46	0,01	143,17	0,01	151,05	0,08	148,74	0,09	130,77	0,039	0,50	12,49941347	12,53036459	100,2%
BOSCO DEBERNARDI	193_T10A1	0,084	0,000	53,46	0,01	309,45	0,01	317,93	0,05	317,85	0,08	281,08	0,035	2,40	12,35908027	11,35193062	91,9%
BOSCO DEBERNARDI	193_T10A3	0,082	0,000	53,46	0,01	309,45	0,01	317,93	0,05	317,85	0,08	281,08	0,035	2,34	12,35908027	11,35193062	91,9%
BOSCO DEBERNARDI	193_T10B1	0,055	0,000	53,46	0,01	313,82	0,01	322,15	0,05	322,07	0,08	284,88	0,035	1,58	12,03761027	10,99300757	91,3%
BOSCO DEBERNARDI	193_T10B3	0,048	0,000	53,46	0,01	313,82	0,01	322,15	0,05	322,07	0,08	284,88	0,035	1,39	12,03761027	10,99300757	91,3%
BOSCO DEBERNARDI	193_T11A1	0,034	0,000	53,46	0,01	584,03	0,02	583,97	0,03	582,69	0,04	509,25	0,013	2,68	4,777261697	4,36620582	91,4%
BOSCO DEBERNARDI	193_T11A3	0,024	0,000	53,46	0,01	584,03	0,02	583,97	0,03	582,69	0,04	509,25	0,013	1,88	4,777261697	4,36620582	91,4%
BOSCO DEBERNARDI	193_T11B1		0,000	53,46	0,01	592,28	0,02	591,26	0,03	589,99	0,04	515,51	0,013		4,650538512	4,244827649	91,3%
BOSCO DEBERNARDI	193_T11B3	0,027	0,000	53,46	0,01	592,28	0,02	591,26	0,03	589,99	0,04	515,51	0,013	2,16	4,650538512	4,244827649	91,3%

GENERAL INPUT		EXPERIMENTAL	METODO EC													
			Fisuración		Yielding		ancho de fisura		Momento úlitmo		Rotura			e ductility capacities (at 90% maxim		
NOMBRE ENSAYO	Beam	θp (rad)	$\phi_{f,D}$ m^{-1}	Mf,D kNm	$\phi_{y,D}$ m^{-1}	My,D kNm	$\phi_{a,D}$ m^{-1}	Ma,D kNm	$\phi_{u,D}$ m^{-1}	Mu,D kNm	$\phi_{r,D}$ m^{-1}	Mr,D kNm	**ERROR**	μ _Without shear	μ _With shear effect	%
DEBERNARDI [May 2002]	T1A1	0,102	0,0014	2,00	0,02	10,57	0,09	10,89	0,15	10,89	0,14	9,83	4,51	6,508182	5,855566	90,0%
DEBERNARDI [May 2002]	T1A3	0,140	0,0014	2,00	0,02	10,57	0,09	10,89	0,15	10,89	0,14	9,83	6,20	6,508182	5,855566	90,0%
DEBERNARDI [May 2002]	T2A1	0,130	0,0014	2,00	0,02	18,82	0,09	21,01	0,14	20,92	0,07	19,20	14,54	2,882737	2,768397	96,0%
DEBERNARDI [May 2002]	T2A3	0,076	0,0014	2,00	0,02	18,82	0,09	21,01	0,14	20,92	0,07	19,20	8,50	2,882737	2,768397	96,0%
DEBERNARDI [May 2002]	T3A1	0,030	0,0014	2,00	0,02	21,35	0,06	30,21	0,22	30,05	0,04	24,13	6,59	7,588214	2,018703	26,6%
DEBERNARDI [May 2002]	T3A3	0,014	0,0014	2,00	0,02	21,35	0,06	30,21	0,22	30,05	0,04	24,13	3,07	7,588214	2,018703	26,6%
DEBERNARDI [May 2002]	T4A1		0,0007	16,00	0,01	44,99	0,02	47,41	0,11	47,04	0,23	41,90		23,14336	20,09583	86,8%
DEBERNARDI [May 2002]	T4A3	0,165	0,0007	16,00	0,01	44,99	0,02	47,41	0,11	47,04	0,23	41,90	2,60	23,14336	20,09583	86,8%
DEBERNARDI [May 2002]	T5A1	0,112	0,0007	16,00	0,01	87,81	0,03	90,58	0,07	90,58	0,06	81,17	8,61	6,365936	4,891612	76,8%
DEBERNARDI [May 2002]	T5A3	0,094	0,0007	16,00	0,01	87,81	0,03	90,58	0,07	90,58	0,06	81,17	7,23	6,365936	4,891612	76,8%
DEBERNARDI [May 2002]	T6A1	0,027	0,0007	16,00	0,01	146,94	0,04	169,18	0,04	168,90	0,02	149,08	8,67	3,363208	1,937102	57,6%
DEBERNARDI [May 2002]	T6A3	0,016	0,0007	16,00	0,01	146,94	0,04	169,18	0,04	168,90	0,02	149,08	5,14	3,363208	1,937102	57,6%
DEBERNARDI [May 2002]	T7A1	0,008	0,0007	16,00	0,01	159,08	0,03	229,89	0,07	229,73	0,02	145,20	2,79	4,683728	1,859776	39,7%
DEBERNARDI [May 2002]	T7A3	0,013	0,0007	16,00	0,01	159,08	0,03	229,89	0,07	229,73	0,02	145,20	4,53	4,683728	1,859776	39,7%
DEBERNARDI [May 2002]	T8A1	0,047	0,0005	54,00	0,01	71,34	0,01	80,07	0,10	74,88	0,15	64,98	0,87	23,45385	18,20961	77,6%
DEBERNARDI [May 2002]	T8A3	0,083	0,0005	54,00	0,01	71,34	0,01	80,07	0,10	74,88	0,15	64,98	1,54	23,45385	18,20961	77,6%
DEBERNARDI [May 2002]	T9A1		0,0005	54,00	0,01	140,00	0,01	148,16	0,08	146,33	0,11	128,77		16,86128	13,75638	81,6%
DEBERNARDI [May 2002]	T9A3	0,079	0,0005	54,00	0,01	140,00	0,01	148,16	0,08	146,33	0,11	128,77	2,03	16,86128	13,75638	81,6%
DEBERNARDI [May 2002]	T10A1	0,039	0,0005	54,00	0,01	306,15	0,02	316,12	0,05	316,10	0,03	279,95	4,30	6,35315	4,122036	64,9%
DEBERNARDI [May 2002]	T10A3	0,043	0,0005	54,00	0,01	306,15	0,02	316,12	0,05	316,10	0,03	279,95	4,74	6,35315	4,122036	64,9%
DEBERNARDI [May 2002]	T11A1	0,011	0,0005	54,00	0,01	526,63	0,02	596,26	0,02	595,38	0,01	506,06	4,32	2,965473	1,898725	64,0%
DEBERNARDI [May 2002]	T11A3	0,011	0,0005	54,00	0,01	526,63	0,02	596,26	0,02	595,38	0,01	506,06	4,32	2,965473	1,898725	64,0%
MATTOCK (1965)	A1	0,057	0,0008	6,38	0,01	40,77	0,08	43,22	0,12	43,21	0,12	39,59	2,29	12,60279	11,54115	91,6%
MATTOCK (1965)	A2	0,056	0,0007	6,38	0,01	41,18	0,08	43,79	0,13	43,79	0,11	40,03	2,33	12,03089	10,92889	90,8%
MATTOCK (1965)	A3	0,053	0,0007	6,38	0,01	43,57	0,08	46,16	0,12	46,15	0,10	42,22	2,43	10,23167	9,102168	89,0%
MATTOCK (1965)	A4	0,035	0,0007	6,38	0,01	78,68	0,07	83,18	0,13	83,18	0,09	75,24	1,95	8,23958	7,483214	90,8%
MATTOCK (1965)	A5	0,028	0,0007	6,38	0,01	78,42	0,06	82,37	0,13	82,37	0,05	74,42	3,06	4,757766	4,416975	92,8%
MATTOCK (1965)	A6	0,024	0,0007	6,38	0,01	81,90	0,06	85,87	0,13	85,87	0,04	77,51	3,08	4,001905	3,739583	93,4%
MATTOCK (1965)	B1	0,035	0,0004	23,27	0,01	170,28	0,06	181,94	0,06	181,94	0,04	173,61	2,58	8,363115	7,980768	95,4%
MATTOCK (1965)	B2	0,035	0,0004	23,27	0,00	167,01	0,06	178,45	0,06	178,45	0,04	170,29	2,60	8,448639	8,143758	96,4%
MATTOCK (1965)	B3	0,019	0,0004	23,27	0,01	320,75	0,03	337,17	0,04	337,17	0,01	306,58	7,50	2,278437	2,152519	94,5%
MATTOCK (1965)	B4	0,015	0,0004	23,27	0,01	320,75	0,03	336,95	0,04	336,95	0,01	306,25	6,15	2,268335	2,139781	94,3%
MATTOCK (1965)	C1	0,051	0,0008	6,39	0,01	42,40	0,08	44,34	0,09	44,32	0,09	40,76	2,83	8,787462	7,884777	89,7%
MATTOCK (1965)	C2	0,044	0,0008	6,39	0,01	42,38	0,08	44,23	0,09	44,21	0,07	40,67	3,08	7,21019	6,670816	92,5%
MATTOCK (1965)	C2A	0,044	0,0008	6,39	0,01	42,06	0,08	44,07	0,10	44,04	0,08	40,50	2,81	7,900984	7,312599	92,6%
MATTOCK (1965)	C2B	0,044	0,0008	6,39	0,01	41,36	0,07	43,04	0,09	43,04	0,06	38,33	4,08	8,358064	5,369278	64,2%
MATTOCK (1965)	C3	0,042	0,0008	5,79	0,01	42,51	0,08	44,34	0,09	44,32	0,07	40,77	3,03	6,954416	6,402409	92,1%
MATTOCK (1965)	C4	0,026	0,0008	5,79	0,01	80,72	0,04	80,37	0,17	80,37	0,07	72,13	1,93	13,84398	5,723698	41,3%
MATTOCK (1965)	C5	0,017	0,0008	5,79	0,01	81,29	0,03	79,39	0,19	79,39	0,03	71,04	3,56	15,56121	2,643267	17,0%
MATTOCK (1965)	C5A		0,0007	5,79	0,01	79,81	0,04	80,95	0,15	80,95	0,04	72,87		3,670728	3,333829	90,8%
MATTOCK (1965)	C5B		0,0007	5,79	0,01	79,76	0,04	78,55	0,17	78,55	0,03	69,10		14,45607	2,736004	18,9%
MATTOCK (1965)	C6	0,018	0,0007	5,79	0,01	79,24	0,04	79,76	0,16	79,76	0,03	71,67	3,79	13,17591	2,740948	20,8%
MATTOCK (1965)	D1	0,029	0,0004	21,09	0,00	164,74	0,04	172,51	0,06	172,51	0,03	164,42	3,62	5,483693	5,367463	97,9%
MATTOCK (1965)	D2	0,025	0,0004	21,09	0,00	163,20	0,04	170,64	0,06	170,64	0,03	162,63	3,27	5,351569	5,211335	97,4%
MATTOCK (1965)	D2A	0,025	0,0004	21,09	0,00	158,57	0,04	166,30	0,06	166,30	0,03	158,62	3,13	5,689265	5,557694	97,7%
MATTOCK (1965)	D3	0,013	0,0004	22,62	0,01	316,39	0,02	311,92	0,05	311,92	0,01	202,08	6,85	8,086923	1,844863	22,8%
MATTOCK (1965)	D4	0,009	0,0004	22,62	0,01	318,53	0,02	315,16	0,05	315,16	0,01	207,22	4,96	7,889756	1,847904	23,4%
MATTOCK (1965)	D4A	0,009	0,0004	22,62	0,01	304,32	0,02	305,70	0,04	305,70	0,01	216,81	4,70	7,714733	1,949511	25,3%
MATTOCK (1965)	E1	0,042	0,0007	5,79	0,01	52,13	0,08	53,91	0,09	53,86	0,08	49,73	2,26	7,02426	6,347607	90,4%
MATTOCK (1965)	E2	0,037	0,0007	5,79	0,01	53,42	0,08	55,18	0,09	55,10	0,08	50,82	2,05	6,602875	5,997687	90,8%
MATTOCK (1965)	E3	0,036	0,0007	5,79	0,01	53,24	0,08	55,12	0,09	55,08	0,09	50,80	1,87	7,043738	6,370451	90,4%
MATTOCK (1965)	F1	0,052	0,0007	5,79	0,01	52,36	0,08	54,94	0,10	54,91	0,11	50,54	2,01	9,267638	8,528157	92,0%
MATTOCK (1965)	F2	0,046	0,0007	5,79	0,01	53,79	0,08	56,37	0,10	56,34	0,10	51,76	1,88	8,522685	7,82743	91,8%
MATTOCK (1965)	F3	0,045	0,0007	5,79	0,01	53,81	0,08	56,47	0,10	56,44	0,11	51,81	1,78	8,800412	7,859774	89,3%
MATTOCK (1965)	G1	0,030	0,0004	21,09	0,01	162,83	0,05	169,98	0,05	169,98	0,03	162,75	2,99	5,189726	5,060783	97,5%
MATTOCK (1965)	G2	0,028	0,0004	21,09	0,01	162,89	0,05	170,16	0,05	170,16	0,03	162,85	2,74	5,314599	5,132715	96,6%
MATTOCK (1965)	G3	0,023	0,0004	21,09	0,01	214,12	0,03	221,28	0,06	221,28	0,02	210,89	3,54	3,633451	3,526612	97,1%
MATTOCK (1965)	G4	0,019	0,0004	21,09	0,01	214,02	0,03	220,58	0,06	220,58	0,02	210,32	3,07	3,4845	3,373614	96,8%
MATTOCK (1965)	G5	0,042	0,0004	21,09	0,01	111,02	0,04	116,10	0,07	115,76	0,05	111,81	2,26	9,348108	8,767126	93,8%
Corley (1966)	J1	0,235	0,0013	0,88	0,03	10,52	0,12	10,54	0,19	10,54	0,15	9,53	8,63	5,537168	4,994479	90,2%
Corley (1966)	J11	0,209	0,0013	0,86	0,03	10,50	0,11	10,53	0,20	10,52	0,14	9,53	8,33	5,144588	4,655488	90,5%
Corley (1966)	J2	0,210	0,0014	0,86	0,03	10,31	0,11	10,28	0,20	10,26	0,12	9,42	10,77	4,270755	3,894215	91,2%
Corley (1966)	J21	0,219	0,0014	0,86	0,03	10,37	0,11	10,31	0,20	10,29	0,12	9,42	10,55	4,478047	4,062195	90,7%
Corley (1966)	J3	0,453	0,0014	0,86	0,03	10,51	0,10	11,89	0,20	11,85	0,07	10,68	45,38	2,28013	2,209999	96,9%
Corley (1966)	J4	0,163	0,0014	0,86	0,03	11,28	0,08	14,99	0,25	14,78	0,06	10,72	19,92	6,834451	2,06839	30,3%
Corley (1966)	J41	0,155	0,0014	0,86	0,03	11,26	0,08	14,98	0,25	14,77	0,06	10,68	19,08	6,881021	2,067803	30,1%
Corley (1966)	J42	0,132	0,0013	0,86	0,03	11,42	0,08	15,07	0,24	14,89	0,06	10,83	16,15	6,578017	2,057236	31,3%
Corley (1966)	J5	0,292	0,0014	0,86	0,03	11,80	0,08	14,41	0,25	14,25	0,06	11,10	41,25	7,651413	2,09388	27,4%
Corley (1966)	J6	0,109	0,0013	0,86	0,03	11,84	0,08	14,67	0,25	14,50	0,06	11,04	15,19	7,543059	2,123746	28,2%
Corley (1966)	J61	0,116	0,0013	0,86	0,03	11,86	0,09	14,56	0,25	14,40	0,06	11,08	16,36	7,579362	2,128333	28,1%
Corley (1966)	K1	0,030	0,0007	2,90	0,02	41,41	0,05	44,51	0,12	44,45	0,03	34,36	9,28	7,129066	#N/A	#N/A
Corley (1966)	K10	0,044	0,0008	11,58	0,01	107,06	0,06	108,73	0,09	108,70	0,07	98,40	2,81	5,286554	4,794178	90,7%
Corley (1966)	K11	0,100	0,0007	11,58	0,01	107,09	0,06	108,98	0,08	108,90	0,19	98,62	2,00	14,43243	12,81367	88,8%
Corley (1966)	K12	0,025	0,0008	11,58	0,01	107,49	0,06	108,85	0,09	108,83	0,07	98,50	1,66	5,105599	4,635855	90,8%
Corley (1966)	K2	0,031	0,0007	2,90	0,01	40,77	0,06	41,86	0,11	41,86	0,03	33,77	9,68	7,344554	1,757048	23,9%
Corley (1966)	K3	0,060	0,0007	2,90	0,02	41,48	0,06	43,23	0,12	43,23	0,03	33,10	19,42	7,346291	#N/A	#N/A
Corley (1966)	K4	0,040	0,0007	2,90	0,01	41,16	0,06	42,39	0,11	42,34	0,03	35,01	12,54	7,154772	1,762195	24,6%
Corley (1966)	K5	0,032	0,0008	8,68	0,01	82,11	0,06	83,63	0,09	83,61	0,07	76,09	2,25	5,097132	4,635485	90,9%
Corley (1966)	K51	0,093	0,0007	8,68	0,01	84,60	0,07	86,91	0,09	86,72	0,12	79,06	3,08	9,168623	8,282276	90,3%
Corley (1966)	K6	0,045	0,0007	8,68	0,01	83,64	0,07	85,40	0,09	85,34	0,07	77,66	3,07	5,098494	4,638352	91,0%
Corley (1966)	K7	0,040	0,0008	8,68	0,01	111,98	0,04	115,13	0,14	115,13	0,06	103,28	3,27	9,42836	3,937901	41,8%
Corley (1966)	K8	0,023	0,0008	8,68	0,01	113,25	0,04	114,97	0,13	114,97	0,04	103,31	2,93	8,793473	2,932364	33,3%
Corley (1966)	K9	0,083	0,0007	11,58	0,01	107,85	0,07	110,40	0,08	110,31	0,10	99,90	3,22	7,951395	7,167995	90,1%

Corley (1966)	M1	0,016	0,0003	46,66	0,01	415,43	0,03	430,17	0,03	430,15	0,02	403,68	2,08	4,161634	3,937944	94,6%
Corley (1966)	M2	0,017	0,0003	46,66	0,01	414,61	0,03	426,96	0,03	426,96	0,02	400,50	2,53	3,854639	3,645603	94,6%
Corley (1966)	M3	0,020	0,0003	46,66	0,01	548,02	0,02	557,93	0,04	557,93	0,02	521,49	4,46	2,875508	2,718219	94,5%
Corley (1966)	M4	0,013	0,0003	46,66	0,01	547,77	0,02	555,75	0,04	555,75	0,02	519,31	3,10	2,786723	2,625012	94,2%
Corley (1966)	M5	0,018	0,0003	62,21	0,01	556,73	0,03	572,08	0,03	572,08	0,02	535,62	2,15	4,497248	4,212432	93,7%
Corley (1966)	M6	0,012	0,0003	62,21	0,01	550,09	0,03	567,32	0,03	567,32	0,02	531,35	1,47	4,559179	4,292408	94,1%
Corley (1966)	M7	0,018	0,0003	62,21	0,01	814,02	0,02	812,92	0,04	812,92	0,02	757,06	4,15	2,815351	2,608395	92,6%
Corley (1966)	M8	0,014	0,0003	62,21	0,01	821,04	0,02	824,39	0,04	824,39	0,02	768,07	3,36	2,783903	2,601484	93,4%
Corley (1966)	N1	0,023	0,0002	71,20	0,00	785,56	0,02	807,29	0,03	807,29	0,01	765,29	4,45	3,285263	3,148722	95,8%
Corley (1966)	N2	0,019	0,0003	71,20	0,00	775,62	0,02	796,53	0,03	796,53	0,01	755,07	3,75	3,291422	3,155926	95,9%
Corley (1966)	N3	0,042	0,0002	71,20	0,00	863,42	0,02	883,21	0,03	883,21	0,01	836,49	9,58	2,966588	2,846516	96,0%
Corley (1966)	N4	0,022	0,0003	71,20	0,00	856,81	0,02	869,67	0,03	869,67	0,01	823,33	5,77	2,777893	2,658231	95,7%
Corley (1966)	N5	0,028	0,0003	94,94	0,00	737,52	0,02	761,10	0,03	761,10	0,02	722,44	3,39	4,898486	4,659133	95,1%
Corley (1966)	N6	0,018	0,0003	94,94	0,00	745,38	0,02	765,07	0,02	765,07	0,02	725,92	2,44	4,522681	4,311277	95,3%
Corley (1966)	N7	0,016	0,0002	94,94	0,00	1148,82	0,02	1171,10	0,03	1171,10	0,01	1106,31	3,27	3,269164	3,118453	95,4%
Corley (1966)	N8	0,012	0,0003	94,94	0,00	1156,39	0,02	1162,74	0,03	1162,74	0,01	1097,41	2,79	2,909332	2,744536	94,3%
KWAK (2007)	BEAMR6	0,075	0,0006	20,14	0,01	196,87	0,05	203,97	0,08	203,77	0,19	198,84	1,22	21,41267	19,9224	93,0%
KWAK (2007)	BEAMR4	0,055	0,0007	20,14	0,01	194,27	0,05	203,02	0,06	202,80	0,07	192,22	2,80	7,307274	6,867086	94,0%
KWAK (2007)	BEAMS1	0,107	0,0008	7,55	0,02	68,63	0,05	70,00	0,07	69,98	0,34	63,10	1,12	24,82784	22,09292	89,0%
KWAK (2007)	COLUMN1	0,009	0,0003	47,36	0,00	792,34	0,01	998,61	0,07	998,61	0,01	546,86	5,09	13,26775	#N/A	#N/A
BOSCO DEBERNARDI	193_T1A1	0,146	0,0010	1,98	0,02	10,68	0,06	10,95	0,16	10,95	0,15	9,85	4,27	6,905968	6,588141	95,4%
BOSCO DEBERNARDI	193_T1A3	0,151	0,0010	1,98	0,02	10,68	0,06	10,96	0,16	10,95	0,15	9,85	4,42	6,90021	6,580486	95,4%
BOSCO DEBERNARDI	193_T1B1	0,044	0,0010	1,98	0,02	10,83	0,06	11,10	0,16	11,10	0,15	9,99	1,29	7,160311	6,269598	87,6%
BOSCO DEBERNARDI	193_T1B3	0,049	0,0010	1,98	0,02	10,83	0,06	11,10	0,16	11,10	0,15	9,99	1,45	7,160311	6,269598	87,6%
BOSCO DEBERNARDI	193_T2A1	0,145	0,0010	1,98	0,02	20,79	0,10	21,07	0,12	21,03	0,08	19,27	10,78	3,291835	3,025508	91,9%
BOSCO DEBERNARDI	193_T2A3	0,124	0,0010	1,98	0,02	20,79	0,10	21,07	0,12	21,03	0,08	19,27	9,18	3,291835	3,025508	91,9%
BOSCO DEBERNARDI	193_T2B1	0,107	0,0010	1,98	0,03	21,08	0,10	21,35	0,12	21,31	0,07	19,53	8,11	3,203365	2,944646	91,9%
BOSCO DEBERNARDI	193_T2B3	0,051	0,0010	1,98	0,03	21,08	0,10	21,35	0,12	21,31	0,07	19,53	3,83	3,203365	2,944646	91,9%
BOSCO DEBERNARDI	193_T3A1	0,085	0,0010	1,98	0,02	24,96	0,07	30,50	0,19	30,31	0,04	25,35	14,40	7,166455	1,944207	27,1%
BOSCO DEBERNARDI	193_T3A3	0,019	0,0010	1,98	0,02	24,96	0,07	30,50	0,19	30,31	0,04	25,35	3,28	7,166455	1,944207	27,1%
BOSCO DEBERNARDI	193_T3B1	0,065	0,0010	1,98	0,02	24,96	0,06	30,89	0,19	30,68	0,04	25,41	10,88	7,152476	1,946299	27,2%
BOSCO DEBERNARDI	193_T3B3	0,023	0,0010	1,98	0,02	24,96	0,06	30,89	0,19	30,68	0,04	25,41	3,78	7,152476	1,946299	27,2%
BOSCO DEBERNARDI	193_T4A1	0,179	0,0005	15,84	0,01	45,38	0,02	47,73	0,11	47,19	0,23	41,94	2,27	23,6278	20,29748	85,9%
BOSCO DEBERNARDI	193_T4A3	0,218	0,0005	15,84	0,01	45,38	0,02	47,73	0,11	47,19	0,23	41,94	2,77	23,6278	20,29748	85,9%
BOSCO DEBERNARDI	193_T4B1	0,031	0,0005	15,84	0,01	46,02	0,02	48,35	0,11	47,83	0,14	42,39	0,67	10,9281	12,82337	117,3%
BOSCO DEBERNARDI	193_T4B3	0,029	0,0005	15,84	0,01	46,02	0,02	48,35	0,11	47,83	0,14	42,39	0,63	10,9281	12,82337	117,3%
BOSCO DEBERNARDI	193_T5A1	0,147	0,0005	15,84	0,01	88,74	0,03	91,10	0,08	91,07	0,06	81,43	8,11	7,028197	5,540211	78,8%
BOSCO DEBERNARDI	193_T5A3	0,237	0,0005	15,84	0,01	88,74	0,03	91,10	0,08	91,07	0,06	81,43	13,13	7,028197	5,540211	78,8%
BOSCO DEBERNARDI	193_T5B1	0,048	0,0005	15,84	0,01	89,99	0,03	92,31	0,08	92,29	0,06	82,54	2,68	6,863895	5,362351	78,1%
BOSCO DEBERNARDI	193_T5B3	0,037	0,0005	15,84	0,01	89,99	0,03	92,31	0,08	92,29	0,06	82,54	2,08	6,863895	5,362351	78,1%
BOSCO DEBERNARDI	193_T6A1	0,041	0,0005	15,84	0,01	169,86	0,04	170,37	0,04	170,27	0,02	150,44	9,70	3,377139	1,965224	58,2%
BOSCO DEBERNARDI	193_T6A3	0,028	0,0005	15,84	0,01	169,86	0,04	170,37	0,04	170,27	0,02	150,44	6,72	3,377139	1,965224	58,2%
BOSCO DEBERNARDI	193_T6B1	0,055	0,0005	15,84	0,01	172,26	0,04	172,51	0,04	172,44	0,02	152,32	13,38	3,287259	1,909463	58,1%
BOSCO DEBERNARDI	193_T6B3		0,0005	15,84	0,01	172,26	0,04	172,51	0,04	172,44	0,02	152,32		3,287259	1,909463	58,1%
BOSCO DEBERNARDI	193_T7A1	0,007	0,0005	15,84	0,01	191,23	0,03	236,34	0,06	235,67	0,02	166,97	2,12	4,312851	1,796152	41,6%
BOSCO DEBERNARDI	193_T7A3	0,006	0,0005	15,84	0,01	191,23	0,03	236,34	0,06	235,67	0,02	166,97	1,69	4,312851	1,796152	41,6%
BOSCO DEBERNARDI	193_T7B1	0,006	0,0005	15,84	0,01	191,23	0,03	239,15	0,06	238,41	0,02	167,00	1,56	4,311648	1,79488	41,6%
BOSCO DEBERNARDI	193_T7B3	0,013	0,0005	15,84	0,01	191,23	0,03	239,15	0,06	238,41	0,02	167,00	3,80	4,311648	1,79488	41,6%
BOSCO DEBERNARDI	193_T8A1	0,054	0,0003	53,46	0,01	71,84	0,01	80,44	0,11	74,83	0,15	65,03	0,85	24,45555	19,17894	78,4%
BOSCO DEBERNARDI	193_T8A3	0,097	0,0003	53,46	0,01	71,84	0,01	80,44	0,11	74,83	0,15	65,03	1,52	24,45555	19,17894	78,4%
BOSCO DEBERNARDI	193_T8B1	0,020	0,0003	53,46	0,01	72,86	0,01	81,04	0,11	75,86	0,09	65,74	0,53	17,84164	12,80535	71,8%
BOSCO DEBERNARDI	193_T8B3	0,020	0,0003	53,46	0,01	72,86	0,01	81,04	0,11	75,86	0,09	65,74	0,54	17,84164	12,80535	71,8%
BOSCO DEBERNARDI	193_T9A1	0,074	0,0003	53,46	0,01	141,18	0,01	149,16	0,08	146,74	0,12	128,96	1,47	18,73692	16,0487	85,7%
BOSCO DEBERNARDI	193_T9A3	0,103	0,0003	53,46	0,01	141,18	0,01	149,16	0,08	146,74	0,12	128,96	2,05	18,73692	16,0487	85,7%
BOSCO DEBERNARDI	193_T9B1	0,017	0,0003	53,46	0,01	143,17	0,01	151,05	0,08	148,74	0,09	130,77	0,42	12,49941	12,53036	100,2%
BOSCO DEBERNARDI	193_T9B3	0,020	0,0003	53,46	0,01	143,17	0,01	151,05	0,08	148,74	0,09	130,77	0,50	12,49941	12,53036	100,2%
BOSCO DEBERNARDI	193_T10A1	0,084	0,0003	53,46	0,01	309,45	0,01	317,93	0,05	317,85	0,03	281,08	6,99	7,071577	4,645568	65,7%
BOSCO DEBERNARDI	193_T10A3	0,082	0,0003	53,46	0,01	309,45	0,01	317,93	0,05	317,85	0,03	281,08	6,83	7,071577	4,645568	65,7%
BOSCO DEBERNARDI	193_T10B1	0,055	0,0003	53,46	0,01	313,82	0,01	322,15	0,05	322,07	0,03	284,88	4,64	6,899361	4,541311	65,8%
BOSCO DEBERNARDI	193_T10B3	0,048	0,0003	53,46	0,01	313,82	0,01	322,15	0,05	322,07	0,03	284,88	4,06	6,899361	4,541311	65,8%
BOSCO DEBERNARDI	193_T11A1	0,034	0,0003	53,46	0,01	584,03	0,02	583,97	0,03	582,69	0,01	509,25	11,77	3,288762	1,80376	54,8%
BOSCO DEBERNARDI	193_T11A3	0,024	0,0003	53,46	0,01	584,03	0,02	583,97	0,03	582,69	0,01	509,25	8,28	3,288762	1,80376	54,8%
BOSCO DEBERNARDI	193_T11B1		0,0003	53,46	0,01	592,28	0,02	591,26	0,03	589,99	0,01	510,03		3,202235	1,776205	55,5%
BOSCO DEBERNARDI	193_T11B3	0,027	0,0003	53,46	0,01	592,28	0,02	591,26	0,03	589,99	0,01	510,03	9,49	3,202235	1,776205	55,5%